STORAGE IMPROVEMENT OF A SMALL RETAILER

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งานวิจัยนี้ได้ทำการปรับปรุงระบบการจัดการคลังสินค้าและการจัดการกับสินค้าภายในคลังสินค้าของร้านค้าปลีกขนาดเล็กในกรุงเทพมหานคร วัตถุประสงค์ของงานวิจัยคือเพื่อให้สามารถรองรับการเจริญเติบโตของร้านค้าในด้านเพิ่มประสิทธิภาพการดำเนินงานของคลังสินค้า เพิ่มพื้นที่การใช้งาน และตอบสนองความพึงพอใจของลูกค้าในด้านเวลาในการรอหยิบสินค้า งานวิจัยนี้เริ่มจากการศึกษาถึงปัญหาของคลังสินค้าในปัจจุบัน ซึ่งปัญหาที่พบคือการดำเนินงานคลังสินค้าอย่างไม่มีระบบและการจัดการ ไม่มีพื้นที่จัดวางสินค้าอย่างชัดเจน อีกทั้งยังรวมไปถึงการไม่มีการจัดการกับสินค้าภายในคลังสินค้าอีกด้วย เมื่อทราบถึงปัญหาที่เกิดขึ้นจึงนำปัญหานั้นมาเป็นแนวทางในการพัฒนาและปรับปรุงการดำเนินงานในคลังสินค้า ขั้นตอนในการปรับปรุงคลังสินค้าเริ่มจากการทำการตรวจสอบประสิทธิภาพการดำเนินงานคลังสินค้าโดยวัดปริมาณพื้นที่ที่ใช้ในการจัดเก็บสินค้าแต่ละประเภท เวลาในการหยิบสินค้า และความถูกต้องแม่นยำในการจดบันทึก เพื่อให้รู้ถึงการดำเนินการจัดการคลังสินค้าในเวลานั้นๆ จากนั้นจึงกำหนดนโยบายที่จะช่วยให้การใช้งานคลังสินค้าเป็นระบบมากยิ่งขึ้น โดยคำนึงถึงการแยกประเภทของสินค้าโดยใช้หลักวิเคราะห์ตามทฤษฎีของเอบีซี การจัดแบบแปลนในการวางสินค้าโดยคำนึงถึงสินค้าที่เป็นสินค้าขายดีตามลำดับ รวมทั้งการกำหนดนโยบายในการจัดการสินค้าภายในคลังสินค้าโดยคำนึงถึงการสั่งซื้อสินค้าจากผู้ผลิตโดยการกำหนดนโยบายในการสั่งซื้อเพื่อลดปริมาณการถือครองสินค้าแต่ยังคำนึงถึงการตอบสนองต่อความต้องการของลูกค้าเป็นหลัก และสร้างกระบวนการในการจัดเก็บสินค้าโดยนำความรู้พื้นฐานของโปรแกรม Microsoft Excel เข้ามาช่วยในการจดบันทึกปริมาณของสินค้าภายในคลังสินค้า จากนั้นจึงทำการตรวจสอบและวัดผลโดยตัววัดประสิทธิภาพของการใช้งานคลังสินค้าที่เห็นได้ชัดเจนหาได้จากพื้นที่การใช้งาน ความถูกต้องแม่นยำในปริมาณการจัดเก็บสินค้า และเวลาที่ใช้ในการหยิบสินค้าเพื่อตอบสนองความต้องการของลูกค้า

ผลจากการปรับปรุงการดำเนินงานคลังสินค้าพบว่า คลังสินค้ามีพื้นที่ว่างเพิ่มมากขึ้นถึงร้อยละ 20 ความถูกต้องแม่นยำในการจัดเก็บสินค้ามีความแม่นยำเพิ่มขึ้นเฉลี่ยร้อยละ 17.40 และการวัดระดับความพึงพอใจของลูกค้าโดยวัดจากการลดลงของเวลาในการหยิบสินค้าของสินค้าในทุกประเภท โดยเวลาที่ใช้ในการหยิบสินค้าลดลงเฉลี่ยร้อยละ 10.73 จากผลการเปลี่ยนแปลงที่เกิดขึ้นสามารถอธิบายได้ว่า กระบวนการปรับปรุงการจัดการคลังสินค้าในงานวิจัยนี้ สามารถเพิ่มประสิทธิภาพในการใช้งานคลังสินค้าและสามารถนำมาปฏิบัติให้เกิดประโยชน์ได้จริง

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SIRION TATTAYATIKOM: STORAGE IMPROVEMENT OF A SMALL RETAILER. ADVISOR: ASST. PROF. PAVEENA CHAOVALITWONGSE, Ph.D., 128 pp.

This research focuses on establishing inventory policy and improving storage operations for a case study which is a small retail shop in Bangkok. The main purpose of this research is to support the growth of small retail shop in the ways to increase efficiency of storage operation, increase storage usage area and satisfy to the customers' satisfaction on time waiting of goods picking. The research starts from studying the current issues of the storage which the problems found are storage operation has no management system, no clear stocking area as well as no inventory management system. The improvement method starts from checking efficiency of the storage operation by measuring the usage area for each type of goods, time of picking and accuracy record in order to know the storage operation at that time. Then setting up policy to support and improve storage usage to be more systematic with categorisation of all types of goods based on analysis of ABC analysis, layout arrangement for stocking area with order of popularity as well as policy set up for inventory management with consideration of purchasing policy in order to reduce the stock keeping unit but still be able to respond mainly to the need of the customer. Finally, measuring of efficiency parameter for storage usage which can be clearly seen from usage area, stock record accuracy and time picking in order to satisfy the need of customer as measured before the start of improvement.

The results from the storage improvement show 20% increased in vacant space within the storage. Also accuracy of stock keeping in each type of goods has been increased by 17.40% on average. The service time to pick goods from storage, which is used as indicator for customers' satisfaction, can be reduced by 10.73%. This suggests the increased in customers' satisfaction. According to the improved results, it can be concluded that the efficiency of storage usage can be increased and applied to work in reality.

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Chapter 1: Introduction

1.1 Introduction

Nowadays, the competition in retail business is high. Retailers have to satisfy the customers' need in which, who can provide more variety of goods with cheaper price will win in the business. Competition in retailer sector is depending on quality of goods, price, and service level. Variety of goods in the stores can be in variety choices for customer. In other ways, variety of goods cause more space of keeping unit and inventory in investment. In both factors, efficient use of storage is one of key requirement to success.

Warehouse or storage refers to a place where to store products in order to support supply uncertainty and demand uncertainty. Warehouse management is the process which consists of layout & mapping, warehouse management system, location control, delivery, and record & data. Bad process in warehouse or storage cause more inventory carrying cost and inefficient use of space. Therefore the improvement in storage management leads to saving space, time, and money.

Storage improvement in a retailer is the main focus for the case study in order to increase efficient use of storage to create more space for variety of goods and increase in service level in term of faster service and higher quality of goods. The way to meet customers' demand and also keep company running effectively is to find the equilibrium point of service level and inventory investment to control amount of goods in storage. The efficiency in using space in storage and storage management leads to many ways to satisfy customers' need and increase in company profit.

1.2 Background of the company

This case study is a retail shop which mainly sells plastic equipment such as plastic container for food, plastic packaging, plastic plates, and plastic bags. Not only plastic but also foam equipment, biodegradable plastic packaging, and rice are sold in the same shop. The shop is located in major market nearby the business area of Bangkok and also close to the university zone. The shop can be easily accessed by cars and public transportations. The facility has small room which has mezzanine floor on top. The shop has variety of plastic materials which sell to individual customers and also ones who have large amount of order. The customers can divided into 2 groups which are retail customers and wholesale customers. Goods in the shop can be divided into 5 big groups which are plastic bags, rice, plastic equipment, biodegradable plastic packaging, and foam equipment. When customers want to buy in small amount of goods, they can buy directly from the shop. However when customers want to buy in large amount of goods, they have to buy in the shop but they need to wait for workers to bring out goods from storage which located nearby the shop except biodegradable plastic packaging. The distance between storage and shop is approximately 100-150 meters and workers can walk back and forth within 3-4 minutes. Storage is a small blog of building 3.5 x 12 meters in size which contains 156 stock keeping units (SKU's) which main products are plastic bags, rice, plastic equipment, and foam equipment as shown in Figure 1.

Figure 1: Stock keeping units in storage: plastic bags (top left), rice (top right), plastic equipment (bottom left), and foam equipment (bottom right)

In each type of products contain variety of brand and variety of suppliers as shown in Table 1.

Table 1: Number of brands, number of types, and number of suppliers in each products range

Products Range	No. of brands	No. of types/Code	No. of suppliers
Plastic bags	5	83	4
Rice	5	7	2
Plastic equipment	6	45	1
Foam equipment	1	21	1
Total	**17**	**156**	**8**

1.3 Statement of problems

From studying the financial statement, the main problems found are that the sale volume increased in small amount as shown in Table 2 but the capability in keeping goods in storage remains the same. Therefore, ability of keeping more inventories is required. But there is an inability of implementing storage expansion due to the storage area of goods which comes as block of building. So the only way to cope with this problem is to do inventory management which at the moment has no adequate system and process. This lack of good system is resulted as stored goods has no order arrangement, difficult to locate, long time taking for picking and finding goods and goods are damaged from storage as will be explained later on. And as shown on the Table 2 which can be seen that the shop has just started recording selling volume and numerical detail. Theoretically, in order to make accurate forecast on next year sale, 3 years of record are required. But in this case we have only 2 years of record sale. Therefore we can only see the trend of sale without having the ability to forecast next year sale volume.

Table 2: Sale volumes in each products range in 2012 – 2013

Product range	2012	2013
Plastic bags (30 kg per pack)	4,005	4,123
Rice (50 kg per sack)	2,064	2,175
Plastic equipment (boxes)	1,162	1,222
Foam equipment (10 bags per pack)	3,175	3,030

As variety of goods in small storage, the space used in storage is limited for small amount of each goods. The shop stores all goods which lead to small space remaining for the popular one. When the shop can only store popular goods in small amount, the shortages of popular goods occurred. Level of service in term of variety

of goods is high, but level of service in term of amount of goods to meet high demand is low. The way to manage space for the increasing capability in keeping goods needs to be adjusted.

From the owner point of view, not only ability of keeping goods is needed but also the process in storage needs to be adjusted. From the preliminary study, there are reasons behind this issue as follows:

1. Inefficient of storage management

   No location of fixed area and fixed layout in storage makes non-sequence and mess up in each type of goods as shown in Figure 2. Goods can be placed anywhere where there are empty spaces. Some goods do not have tag details, so when goods arrived in the storage, workers put away without tag details. This problem leads to problems in finding, counting, using, and bringing out when the shop want to sell the goods. The lack of process in storage shows poor ability in managing and keeping goods which cause the inefficient use of space as mentioned previously. Lack of storage area management also causes the problem to some goods with low selling volume while stocking volume is high. This resulted in loss of usage area for stocking popular goods. Moreover, as the volume of stocking goods is higher than necessary, which this can be purchased directly from supplier when more goods are required by the shop owner, cause loss of use area as well as high inventory carrying cost.

Figure 2: The existing storage

2. Inaccurate record

When workers are putting away or picking goods from storage, they record their number into informal form of stock card as shown in Figure 3. However, when checking the goods in storage and comparing with the record, the owner found the different number. These inaccuracies are caused by two major mistakes which are one is counting mistake and another is miss-recording number.

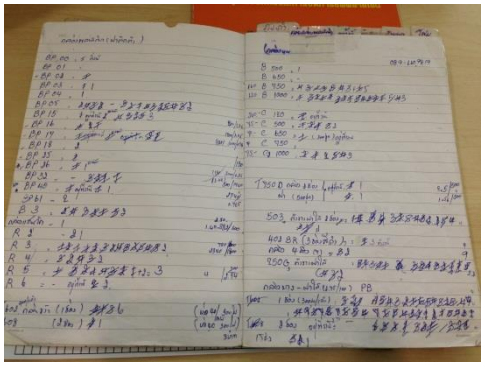


Figure 3: Informal form of stock card.

3. Damage of goods

Goods are kept in overlapping arrangement on the shelves without having category. Goods that came first was sit on the bottom of the shelves and when the new lots came, the new one was put over the old one which cause the old lots to stay longer in shelves and need to carry heavier weight from the new lots. The damage from carrying heavy weight for longer time and expiration of the products cause more carrying cost to the inventory. Most problems occur with plastic equipment and foam equipment in which plastic equipment is fragile items as shown in Figures 4.

Figure 4: Damage of plastic equipment and foam equipment

From complaining of customers, which are the time of waiting for goods is quite long. Workers who needs to find and pick up goods from the storage has no managerial skill and low order management resulted in loss of time in picking goods and this will make the customer do not want to wait and they might go to other shops that have shorter waiting time and higher service level. This problems need to be fixed by categorising goods and making it easy for picking.

From all the problems, these can be seen that the root of problem mostly came from lack of storage management and inventory management. So if all these problems are still existing and lasting, the shop would not grow and be able to compete with other competitors.

1.4 Research objective

The objective of the research is to focus on establishing inventory policy and improving storage operations in order to arrange and develop activities in storage to gain more efficiency of using space as well as better of storage management.

1.5 Scope of research

Scope of this research will focus on storage improvement for the shop to increase the benefit in using space and good management of storage. The scope will be as follows:

- Design the new layout of storage by zoning of receiving area, keeping area, and storage area.
- Categorise goods by ABC analysis.
- Create new operational process in storage by focusing on putting away and picking goods.
- Design new purchasing policy by Fixed-Time Period Ordering System and Fixed-Order Quantity System.
- Design formal form of stock card checking sheet by using Microsoft EXCEL.
- Set policy of using stock card and checking system for workers.

1.6 Methodology

The methodology will be divided into 3 phases as follows:

Phase I – Data and problems collection

1. Identify the problems concern about storage and inventory management.
2. Review the process occurred in storage.
3. Set of variable data to measure change after applied new policies in storage. The data that needs to be collected are capacity of goods in storage, time of picking goods, accuracy record and suppliers limitation data.
4. Set policy and method of collecting data
5. Collect all data needed.

Phase II – Set and use of new policy

This phase can be divided into big 2 scopes as follow:

1. *Storage Management*
   - 1.1 Categorise goods by ABC analysis.
   - 1.2 Design new layout of storage considering zoning system and limitation of goods.
   - 1.3 Set process in storage.
   - 1.4 Set new storage policy.
2. *Inventory Management*
   - 2.1 Set new purchasing policy.
   - 2.2 Create form of stock card and set stock card policy by Microsoft EXCEL.
   - 2.3 Create form of accuracy report and set stock checking policy.

Phase III – Result Analysis

1. Collected data of capacity of goods in storage, time of picking goods, and accuracy record after applied new process and policies into storage.
2. Compare the data before and after applied new process and policies to measure change.

1.7 Expected Benefits

1. More efficient use of storage.
2. Increase capability in keeping goods.
3. Increase accuracy in stock record.
4. Increase service level in term of faster service and decrease time of picking goods.

1.8 Research structure

This research consists of five chapters which are Introduction, Literature Review, As-is Analysis, Proposed Method, Evaluation and Conclusion. Introduction gives an overview of the research, background of the company, statement of problem, objective of the research, scope of the research, methodology, and expected benefit from the research. Literature Review gives the information to support and adapt to the research. As-is Analysis gives the detail of problems that exist to the shop and also proposed solution. Proposed Methods gives the details of bringing knowledge from Literature Review Chapter applied to the problems. Measurement and Conclusion gives the details of results after applying tools to the experiment and conclusion of things that are done from the experiment and advantage suggestion after the improvement.

Chapter 2: Literature Review

This chapter is the reviews of related literatures that were base knowledge of the research. The literatures come from many sources including textbook, case study, and journals. The reviews divided into 2 main scopes which are storage management (warehouse management) and inventory management.

2.1 Storage Management

2.1.1 Important of Warehouse

Apiprushchayasakoun (2007) stated that warehouse management plays important role in Logistics Management through sub-activities related to warehouse management, for example, selection, lay out of warehouse, moving goods in warehouse and so on.

Kittithreerapronchai and Phumchusi (2014), the warehouse plays important role in strategic planning in supply chain. In addition a place to keep inventory for sale or raw materials for production to prevent changes in supply and demand in a short time ago, warehouse also add value to the product, for example, the property and collect items from multiple sources to save on shipping. Moreover, warehouse is a place of final assembly and packaging before shipping to consumers. Nowadays, international business focuses to meet the needs of various clients within the constraints of the organization. Warehouse is a strategic point between producers and consumers. Effective warehouse management is an important factor that can increase the chance to compete in the market.

2.1.2 Layout of Warehouse

According to Heragu, Du, Mantel, and Schuur (2007), Layout design, inventory will focus on two main problems is designing facilities (Facility layout problem) and designing the store to make it easier to pick up (Internal Layout Design or Aisle Configuration Problem). The first part focuses on related activities in warehouse such as picking, receiving or moving. The purpose is to provide low cost, which is presented as a linear function of distance. The second part is called the store layout design for easy picking. The goal is to find the best design under restrictions.

According to Koster, Le-Duc, and Roodbergen (2006), layout design concerns two sub-problems which are the layout of the facility containing the order-picking system and the layout within the order-picking system. The facility layout problem concerns the decision of where to locate each department which are receiving, picking, storage, and shipping which we will apply this type into the research. Another type concerns the aisle configuration problems which are the number of block, length of aisle, and width of aisle.

According to Edgar and Tanyildiz (2009), there might be activities in warehouse that affect to the products such as inner movements to optimize the space and inventory counts on a regular basic. Also one of the important objectives of warehouse layout was space efficiency.

2.1.3 Process in Warehouse

2.1.3.1 Storage and Put away goods

Tompkins and Smith (1998) described in the stock location methodology as 6 ways of storage as follow:

1) Informal system – no fixed location for goods and this system suitable for small warehouse and small number of stock keeping units (SKU's).

Table 3: Pros and cons of Informal system

Pros	Cons
- Low maintenance - High flexibility	- Difficult to find goods - Inefficiency - Depend on worker performance

2) Fixed location system – every stock keeping unit has its own fixed area even though low order quantity during that time, space left make low utilization. This system suitable for small warehouse and small number of stock keeping units (SKU's).

Table 4: Pros and cons of fixed location system

Pros	Cons
- Easy to maintain - Easy to set up the store	- Use a lot of space - Have to set the maximum stock for each SKU's

3) Part number system – similar to fixed location system but sort in the number of goods such as A001 place in front of B001.

Table 5: Pros and Cons of part number system

Pros	Cons
- Easy to find goods - Easy to set up the store	- Difficult to change in quantity of keeping unit - Use a lot of space - Lack of flexibility

4) Commodity system – categorise goods by type of products and fixed location but no fixed area for sub-category like brand or size but product itself as a whole. This system suitable for goods stocking that has more of space utilization and easy for workers to pick up goods.

Table 6: Pros and cons of commodity system

Pros	Cons
- Products are grouped - Increase efficiency in picking - Flexibility	- Workers need to know specification of goods - High probability to pick the wrong goods such as wrong size of goods

5) Random location system – is the system that has no specific location for each type of goods which makes goods available to be placed anywhere in the warehouse, but

this kind of location system needs to have an IT system for locating and following where goods are placed at.

Table 7: Pros and cons of random location system

Pros	Cons
- Efficient use of space - Flexibility - Easy to extend	- Need a good record - Very detailed in the record

6) Combination system – is considered as fix location system for the remaining area in the warehouse due to there are area usage considerations. Therefor goods are stocked or located in the remaining area randomly. This kind of system is suitable for all kinds of warehouse especially large warehouse with various kinds of goods.

Table 8: Pros and cons of combination system

Pros	Cons
- Space utilization - Flexibility - Easy to control	- Create confusion - Need thoroughly storage record

2.1.3.2 Picking goods

According to D. Piasecki , Piece picking is one of method in Order Picking which is picking the goods from storage to meet customer demand by selecting and picking according to desired amount of goods. However, Picking varies depending on product

placement, such as pick-wave (Wave Picking), produced a series (Batch Picking), picks up a piece (Piece Picking).

According to Tharathup (2010), the separation of space in warehouse designed to facilitate and secure storage. So the picking, which is one of the warehouses activities, are considered to be the most costly in the warehouse. A study in England found that 63% of the cost of all operations in the warehouse is the cost of picking.

According to Roodbergen and Petersen (1999), picking process is an activity that is associated with many human workers in the warehouse. Picking in a warehouse is the process of bringing products from the storage according to need of coming customer. The Picking generally regarded as a process that requires the most painstaking process management. It is estimated that require workers to 60% of all labour work in warehouse. Picking activity is an activity that has a highest cost of warehouse operations. The Picking involves with time limitation and the wrong product picking was found to be one of the most common errors. The slower pick is a result of the delay from transportation (bottleneck) that affects the distribution of the organization. Moreover, picking the wrong items and thence sent to the client. The obtained results may be damaged beyond expectation. Thus, the picking is important because it relates to the needs of the customer.

2.2 Inventory Management

2.2.1 Inventory Control

2.2.1.1 Product Category

Wild (2002) described ABC system is the analysis that focuses on the type of goods based on their sale volume from popularity order or profit share of specified goods. Goods in category A include product that has low SKU but has high sale volume or most profit share in group. Category B and C are goods with less sale volume and profit.

Applying this system will show that goods that only 20% of stock quantity will show as many as 70-75% of movement from all types of goods. So as mentioned previously, category A must have close follow up and priority set up prepared by specific shops or company because this is the popular selling product and their location should be easy to access to pick the most, more than category B and C. In addition, more than 3 categories of goods could be set up in order to scatter or allocate the movement percentage of popular selling product.

Table 9: ABC analysis

Category	Quantity	Value	Particulars
A	15% - 20%	70% - 75%	Very important inventory, tight control, close check, low safety stock
B	30% - 40%	15% - 20%	Moderate control, some check, medium safety stock
C	40% - 50%	5% - 10%	Simple physical control, little check, large safety stock

2.2.1.2 Purchasing/Order Cycle

Economic Order Quantity (EOQ)

According to Stevenson (2005), EOQ is goods system that has been widely used for long time. This system is suitable for using with product that has independent need, not relate continuously with other product need. Hence planning for consideration is required for individual product need by direct demand prediction.

Assumption of EOQ

1) Only one product is involve
2) Annual demand requirement know
3) Demand is even throughout the year
4) Lead time does not vary
5) Each order is received in a single delivery
6) There are no quantity discount

According to D. J. Piasecki (2009), about “Optimizing Economic Order Quantity, he mentioned that many companies are no longer having advantage of the EOQ model due to incomplete and misunderstanding of the application use in software technology to aid

them on inventory management. In order to have suitable and accurate inventory model, many factors in inventory management needs to be put in place, for example accurate product cost, activity cost, forecasts, history and lead times. In addition, another reason for having no advantage on EOQ model is because people do not know how it works. They mostly rely on the software calculation without truly understanding and knowing how the data is derived and set up. Many times in most cases, the system could get out of control. So in order to overcome this uncontrollable error, people must understand and have proper EOQ concept knowledge. And most important thing, they need to keep in mind when using the software in running the business is that they are only designed to support, not replaced the traditional way.

According to Gonzalez and Gonzalez (2010), "A Technique for Applying EOQ Models to Retail Cycle Stock Inventories", the article focuses on the application of the EOQ model to small business in order to calculate the order quantity in dollar amount for each supplier. William Bassin illustrated how the EOQ model minimized the total cost of ordering and carrying stock in small businesses. He calculates the order quantities based on existing data in an easy to use Microsoft Excel spread sheet. As a result for using an EOQ system, small businesses could:

1. Saving of yield cost by reducing inventory investments.
2. No measurements and assumption requirement of ordering and carrying costs.
3. The technique to the current mode of doing business.

Reorder point (ROP)

According to Apiprushchayasakoun (2011), for goods purchase in warehouse, time factor is a very important criteria, especially if product controlling system in warehouse is a continuous system, this could be set for reordering when goods in warehouse has been dropped to one certain point, then reordering will be made with stable amount as in the set amount which is called Fixed Order Quantity System. Reordering point has simultaneous relationship with 2 variables which are demand and lead time.

Safety stock (SS)

According to Gonzalez and Gonzalez (2010), goods stocking that are kept in excess of forecasted demand due to variable demand rate and/or lead time. Safety Stocks are needed because customers could buy in bulk conveniently or supply time takes longer than normal required time.

2.2.2 Demand Forecast

According to Apiprushchayasakoun (2011), Demand Forecast is the predictive method to estimate the demand of goods or service in long-term. Sometimes, demand behaves as a random which is irregular. There are 3 types of demand behaviour as following

1. Trend: It is the line of graph that illustrates upward movement or increase continuously.

2. Cycle: It is shown as up and down movement in demand as well as the life cycle of products based on technology, law and political economy as a factor that cannot control.

3. Season: The demand behaves as a period which is influenced by seasonal factor, for example, Lotion in winter.

4. Irregular Variation: The demand happens beyond expectations which have an impact on the sales of products such as natural disasters, epidemics, new discoveries by accident in the laboratory of war. This behaviour cannot be predictable because there is pattern for approval.

2.2.3 Checking System

2.2.3.1 Stock Card

According to Brooks and Wilson (2007), inventory records are hard copy and electronic documents that show on how much and what type inventory are holding, processing, and ordering. The record shows the balance of goods in order to use for purchase, check, and sale which help in inventory management. The benefits in stock record are as follow:

1) Marketing and Sales Planning – The number of storing goods can tell how many goods left that can be sold. Marketing can plan for sell the existing goods.
2) Financial Planning – In term of financial, inventory holding is asset and the record of inventory can be used for historical and future

forecast data in order to calculate profit and loss of the company. Cash-flow also be known by the amount of inventory record.

3) Procurement Planning – The stock record show on-hand inventory, so the company know how many inventory to make an order. Purchasing policy can be set from the stock record.
4) Continuous Improvement – The record can tell excess inventory and show movement and time that help improve the operations process in the company.

2.2.3.2 Cycle Count

According to Apiprushchayasakoun (2011), Stock checking in warehouse is the checking to make sure that goods are truly existed and same as in the record. There are many ways to check as follows;

1. Close account checking method is to choose one day for closing the account and forbid all transaction or movement of all goods in warehouse by stop normal trading list then check and count all goods. This method will show accurate goods' value on the checked day but on the contrary some income will be lost on this day.

2. Rotate checking method will close the goods' movement in warehouse for quantity checking and when one part is done, it will be on sale or allocated normally and then continue closing other department for quantity checking on and on until complete every department. This method will not sacrifice any income from sale but chance of deviation is quite high.

2.2.3.3 Measure of Stock Accuracy

"Accuracy is not always absolute". Brooks and Wilson (2007) accuracy is the number of precision which can be measured by comparing the same group of data as comparing between the number of quantity in stock and quantity in the record. In ideal, we want to do everything perfect but in reality, nothing is perfect. The missing something might happen but the acceptable point could be accepted. Acceptable quantity is set by the company. If the company set acceptable number as 2%, that means the tolerance equal to 2 and the quantity of goods can be between 98 and 102.

Chapter 3: As-is Analysis

In this chapter, problems occurred in storage will be described. To know what problems need to be eliminated is the way to improve. The description of storage process, inventory management, and knowledge and skills of workers will present how the operations proceed in storage. The collected information and data will lead to operational plan for the improvement.

As mentioned in chapter 1, the focus area in this research is the process and activity in storage. Start from the shop received the order from customer then prepare goods as ordered and checked whether it is available at shop or not. If it is available then sell to customer, if not then have to pick goods from storage then prepare and sell to customer again.

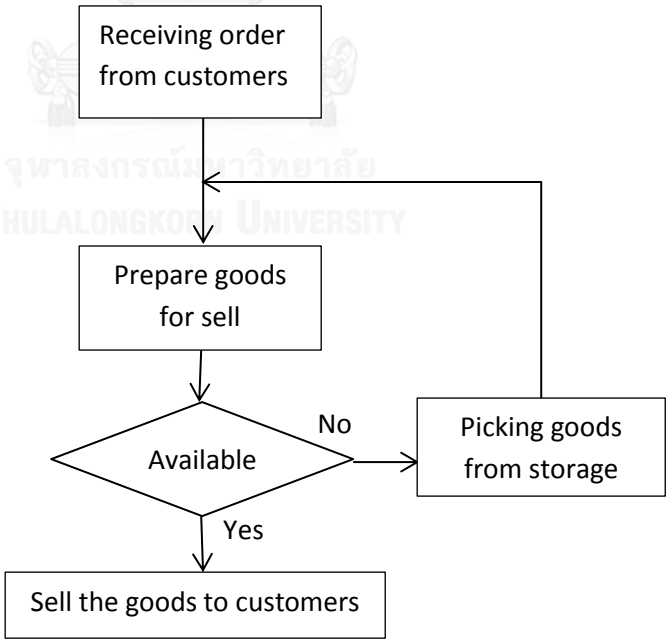


Figure 5: The flow chart of activity occurred in the shop

Layout of storage

Storage has a rectangular shape which encompassed 4 big shelves, 2 small shelve, and 12 pallets. Looking from the entrance, three shelves were placed on the right side of the wall while twelve pallets were placed to the left side of the wall. On goods storage area has no office section but has toilet for workers. When supplier delivered goods, workers put away goods wherever there are emptied spaces without proper arrangement and categorisation. One hundred and fifty-six types of goods were brought into storage without tag and label details.

As shown in the Figure 6, plastic bags are put up on the shelves on the right while rice and foam are put on the pallets on the left. And plastic equipment is put in the back zone without proper arrangement on either shelves or pallet.

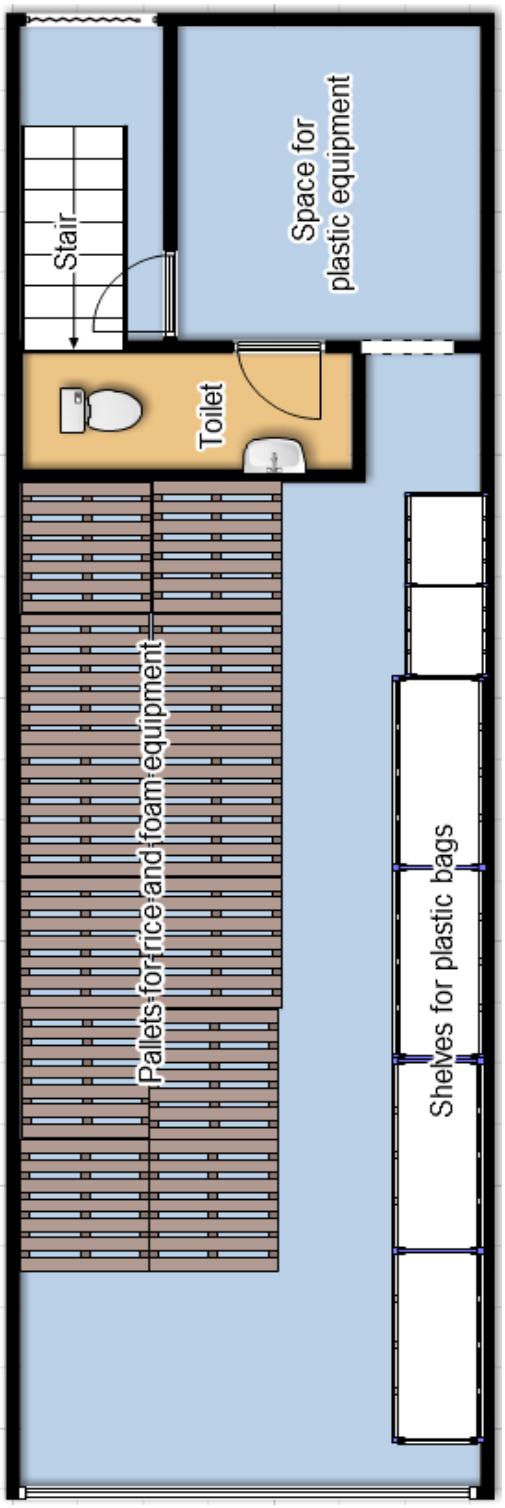


Figure 6: Layout of storage

3.1 As-is process study

The important point from the current process study can be described the problems and things need to be improve as follow. The main points that will be stated is the current on-going issue in storage area in which the problem has been studied by direct information from the owner as well as analysed in details on the mentioned issue in statement of problem in chapter 1 in order to correct and improve directly to the issued points.

3.1.1 Voice of the Owner

From financial statement, there is a small increase in sale volume of all products from 2012-2013 except foam equipment which shows a decrease in sale volume as shown in Table 10 below. This decrease is caused by the university campaign as well as regulation to reduce the use of foam in which the shop is located in the university zone; therefore the effect is shown on the sale volume.

Table 10: Changed in sale volume between 2012-2013

Product range	2012	2013	% Change
Plastic bags (30 kg per pack)	4,005	4,123	2.95
Rice (50 kg per sack)	2,064	2,175	5.38
Plastic equipment (boxes)	1,162	1,222	5.16
Foam equipment (10 bags per pack)	3,175	3,030	-4.47

Even though there is drop in demand of foam but when comparing with rise of other goods' demand, the overall picture still shows that the demand in buying goods still increases with the shop tends to sell more, the necessity of storage volume also comes into the account. But as already mentioned in statement of problem that expansion of storage area cannot be

done with existing area is fully used in capacity for stocking goods. Therefore what can be done is goods storage management, increase order and maximise the full use of area. And another problem that causes an impact to the usage area is having goods more than necessary. In this case means the average selling goods which has over stocking unit while the popular one do not have enough stocking unit to satisfy the need of customer. Therefore in order to maximise the full use of storage area, consideration of SKU on each type of goods must also be taken into the account.

3.1.2 Root Cause Analysis

Root Cause Analysis easily shows root of problems which occurred in storage. The Root Cause of this study can be explained and categorized by 3 fishbone diagrams as shown below.

1) Inefficient use of Storage

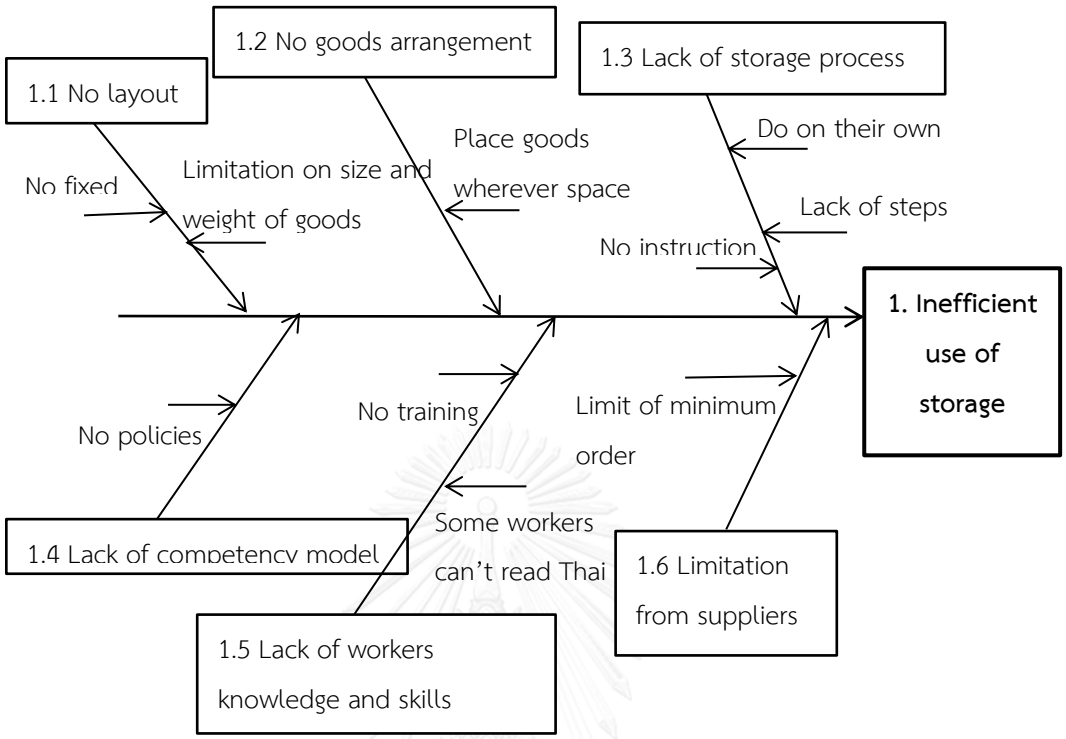


Figure 7: Fishbone Diagram for Inefficient use of storage

Cause of inefficient use of storage

1. No Layout – no specified location and limitation of where to put the goods such as size, weight and characteristic of goods. Damage can be caused by no specified certain location of goods as well as overlapped of many products on one location.
2. No Goods Arrangement – Goods storage without consideration of FIFO system, goods overlapping and goods arrival date recording. These caused goods expiry and damage by selling the new one while previous arrived goods are still in shelves life, and also picking goods from storage cannot be completed in specified time.

3. Lack of storage process – When goods arrived in storage, there is no management or process to handle goods effectively such as how to manage when received goods come, how to identify goods, how to categorise goods, how to put away goods, how to hold goods, how to pick up goods and how to ship goods. This is because workers are not well instructed and no steps assigned to them.
4. Lack of competency – No policies and regulation assigned in the storage.
5. Lack of workers' knowledge and skill – No training are being forced and most of workers are not Thai. So many of them cannot communicate effectively among the others.
6. Limitation from supplier – Good inventory management also required good support from supplier but normally suppliers has minimum number of order which shop owner has to follow. Therefore sometimes this leads to limitation of the shop owner to control quantity of goods in storage.

2) Inaccuracy in stock record

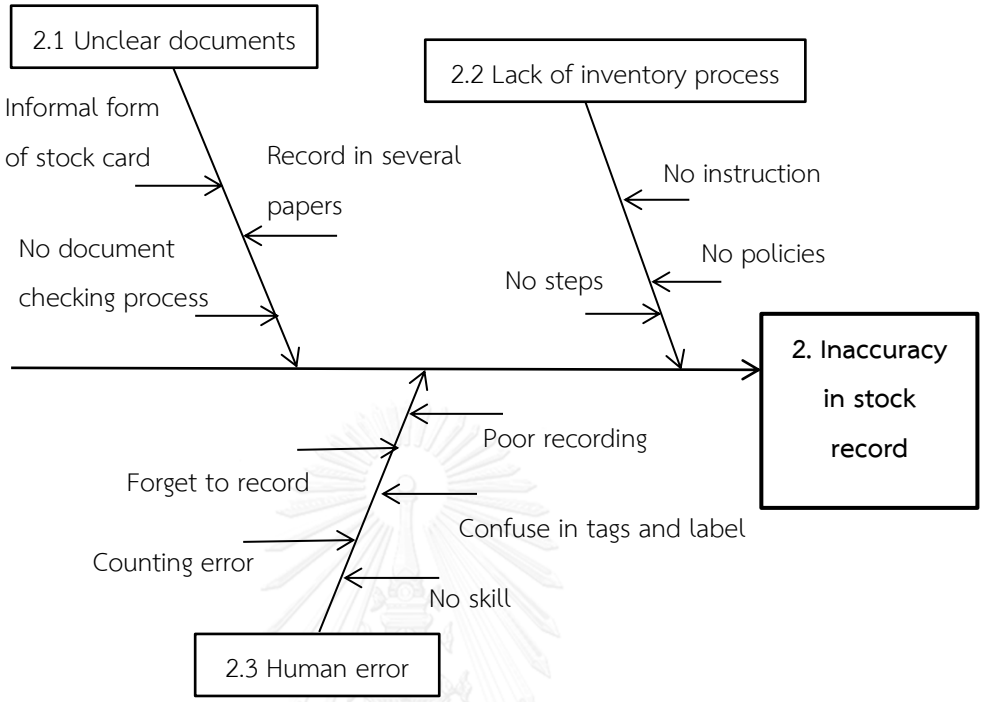


Figure 8: Fishbone Diagram for Inaccuracy in stock record

Cause of inaccuracies in stock record

1. Unclear document – As there is no proper form of document for worker to use in recording of goods. Therefore several improper piece of paper are being used by workers to record goods instead. This lead to loss of paper and misunderstanding of information shown on paper. Also as there are several workers in the storage doing recording work so as there are no formal form of document, each worker use different style of recording, hence cause confusion when checking the recorded document.
2. Lacks of inventory process – There is no given policies in purchasing amount & cycle time to order and no steps assigned on what to do first and second. Therefore this leads to mess up of system.

3. Human Error – As most of workers are foreigners and has low level of education. So they cannot understand and work effectively. For example, stock counting error, no skill to manage stock goods, confusion of tag label, poor recording of stock goods and as well as forget to record stock number.

3) Low service level in term of time picking goods

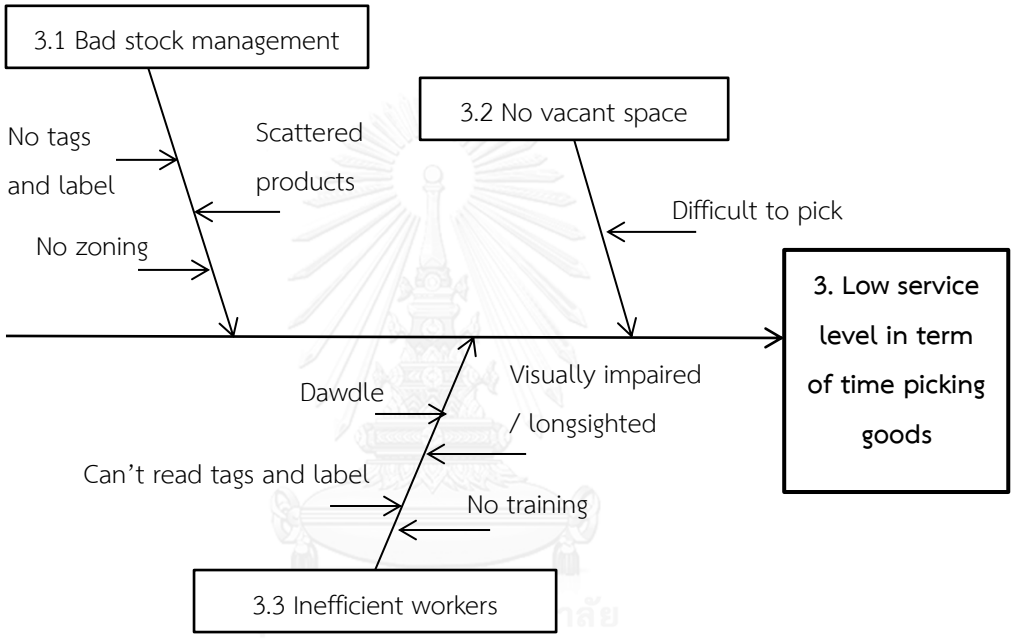


Figure 9: Fishbone Diagram for Low service level in term of time picking goods

Cause of Low service level in term of time picking goods

1. Bad stock management – As goods has no tags and label with no zoning of each type of goods, then most of product are scattered improperly which leads to longer time of picking goods from storage.
2. No vacant space – With bad stock management leads to improper arrangement of goods. Therefore lack of space causes the goods to be placed on overlapping position with other goods which cause difficulty to move and bring out place.
3. Inefficient worker – Inability of workers like lack of vision or minor problem of the body leads to slower and ineffective operation during working time. Also lack of skill training cause the inability to read and understand tags and label.

3.2 Proposed Solution

From 3 stated fishbone diagrams all the problems are being shown clearly. Therefore solution can be initially summarized as 2 following operational plan and research methodology.

From Figure 10 shows that from the problems that caused by worker action, management process or whatever factor that caused damage to the product and low service level to the need of customer, all these lead to the need of improvement process which can be categorised into 2 main issues which are storage management and inventory management. These two separate improvement must be taken parallel and together in order to make an effective result because inventory management is a variable that tells whether the use of storage is effective and efficient or not. The solution that focuses on storage and product inside the storage could lead to the improvement that will increase the effectiveness in better service level to the need of customer.

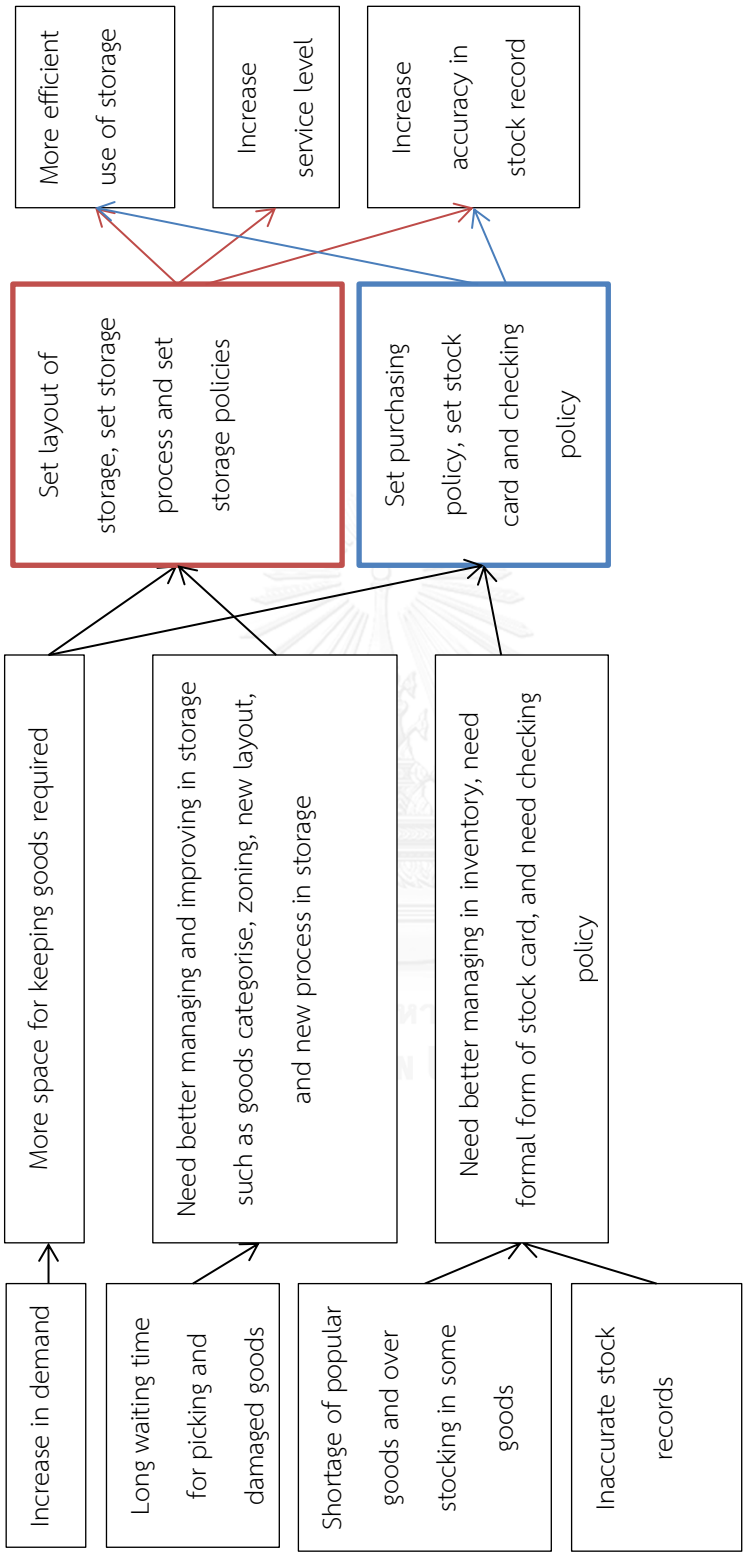


Figure 10: Flow chart show the indicator of this research

3.2.1 Operational plan

From the surveying of root cause analysis, the problems can be categorised into 2 main topics which are storage management and inventory management as following. In storage management part will be the way to correct issue of the on-going storage activity which will emphasize on layout and storage policy set up. For inventory management part will be the way to correct issue on inventory controlling for leading to the problem correction of storage area in order to be effective and better in storage management.

Storage management

As shown in the Figure 11, the lack of stock management and arrangement must be analysed by Pareto Analysis and ABC system in order to categorise goods. Lack of layout and available space is being solved by zoning system in order to specify the appropriate area of goods. Lack of storage process is being solved by creating process in warehouse. For missing of competency model, solution is to set up storage policies. And lack of workers' knowledge and skill will require the training of workers to get used to the new system. All these solutions are required in order to achieve new layout of storage, goods categorisation and systematic process.

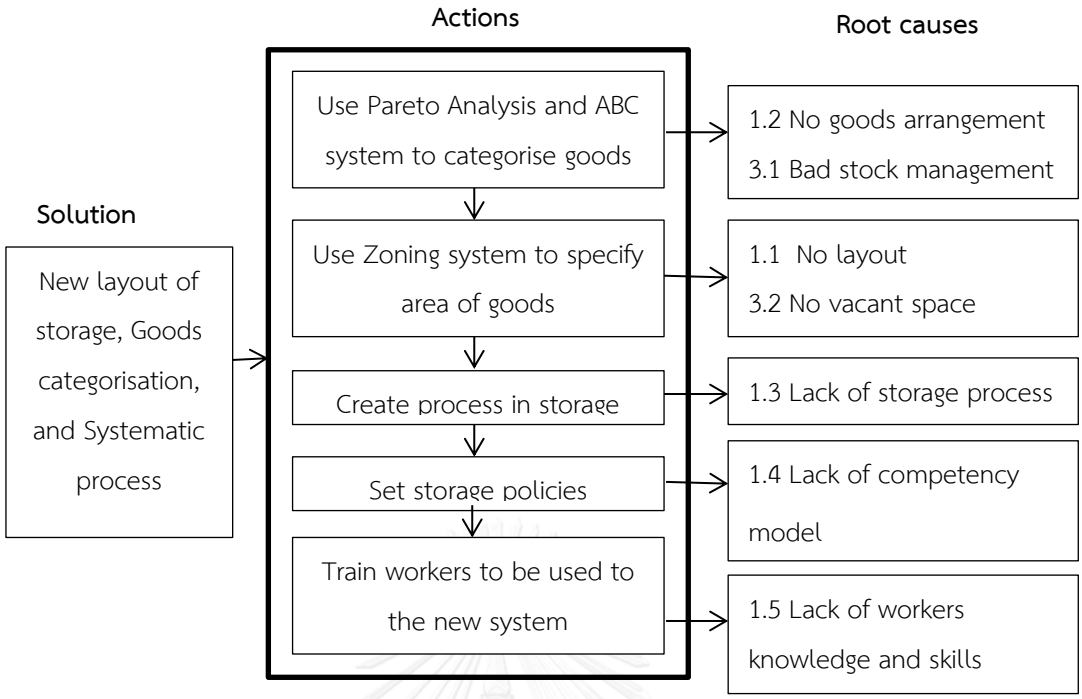


Figure 11: Solution in storage management

Inventory Management

As shown in the Figure 12, the problem in limitation from supplier must be solved by setting up new purchasing policy. Issue on supplier limitation that was already mentioned are caused by inevitable control of suitable goods volume with storage volume. In order to control the goods volume depends on goods purchasing from supplier. Missing of inventory process is being solved by setting up instruction of using stock card, step of checking goods and as well as stock checking policy. For unclear document must be coped by creating formal form of stock card by using Microsoft EXCEL with establishing cycle count sheet for rechecking the quantity of goods weekly for increasing the accuracy of inventory on hand and on paper are the same. And lastly human error and inefficient worker problem will require the training of worker to be familiar with the new system.

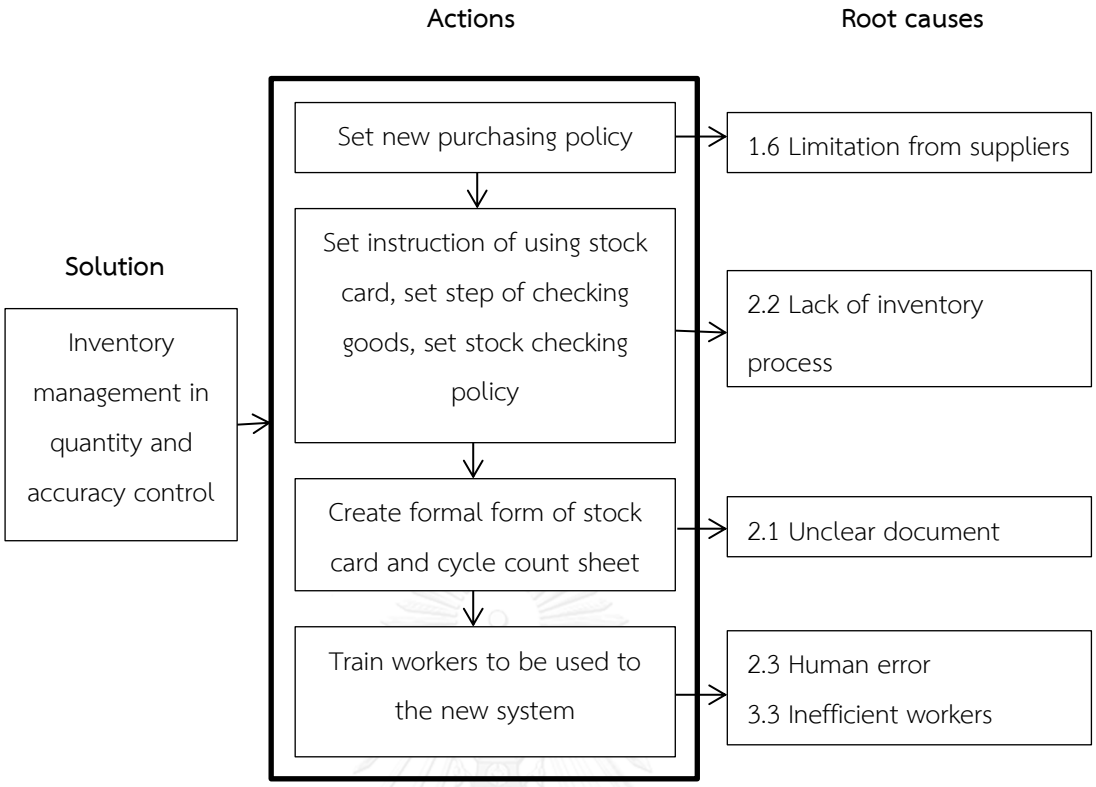


Figure 12: Solution in inventory management

3.2.2 Research Methodology

So the above two operational plans are studied and analysed to bring out the way to solve the problem. With research methodology is the answer to the problem of both storage and inventory management.

Firstly, starting with data collections of capacity of goods, time of picking, purchasing data and record accuracy. Secondly apply and improve both the operational plan for storage and inventory management (Research methodology for improvement has already been stated briefly in operational plan). Then measure and record the data after the use of the new policies. Next is to compare and evaluate the before and after data to see the change with the new system. Finally, conclusion and suggestion must be clearly explained.

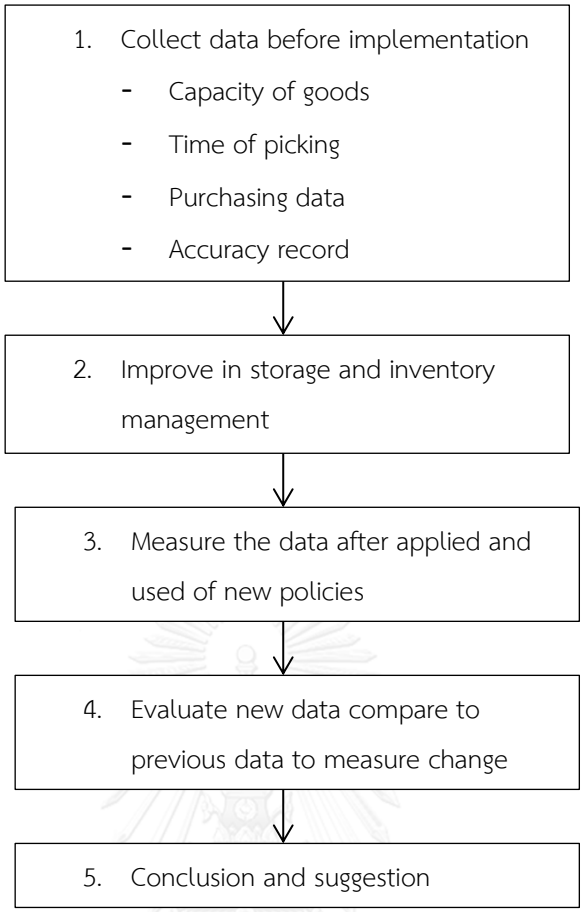


Figure 13: Research Methodology

3.3 As-is Analysis

As-is analysis is the data collection for using as variable in comparison in order to consider whether or not after the improvement process in storage and setting of new policies, the data value has changed into a better way or worse way. If the measured data in this process has improved in a better way that means the implementing process on this thesis has made an effective improvement and can be applied in real use. But if the measured data has shown the drop in value or worsen that means this implementing process is not an effective method and cannot be used in real application.

The collecting data can be categorized into 4 groups which are,

1) Capacity of goods
2) Time of picking
3) Accuracy in stock record
4) Suppliers limitation and purchasing policy

3.3.1 Capacity of goods

The finding of capacity of goods can be done by stocking area calculation on each type of goods because each type of goods has different size, weight and limitation. Types of goods can be grouped into the following Table 11. Goods arrangement on shelves consists of 3 levels of shelves excluding top shelve. One level of big shelve can put plastic bags at maximum no more than 12 packs while small shelve can put plastic bag no more than 9 packs. And on the pallet section will be rice and foam in overlaying arrangement but with categorisation when entering the entrance, the first goods to be on pallet is rice and foam is next which are arrange in section with 6 pallets on each section. 2 pallets can have 3 stacks of rice and on each stack has 15 sacks of rice. For foam is fully used area with 6 pallets. So when calculating for stocking volume, this can be shown further in Table 12

Table 11: Appearance and limitation in each goods

Products	Size / Weight	Remark
Plastic bags	30 kilograms per pack	Can be overlapped and capable of impact resistance as it is heavy
Rice	50 kilograms per sack	Can be overlapped but need to be careful of package torn off from sharp thing.
Plastic equipment	Approximate 8-10 kilograms per box	Fragile material, need to be careful.
Foam equipment	Very light weight	The most fragile goods as it cannot be slammed or overlapped by heavy equipment or goods such as rice bag.

Table 12: Quantity of goods

Products	Storage area	Quantity
Plastic bags	On shelves	198 packs
Rice	On pallets	115 sacks
Plastic equipment	On the floor	40 boxes
Foam equipment	On pallets	1 small truck load

These used areas can be figured out by checking quantity with measured area that is used to store each goods and calculating into percentage for each type of category.

From calculation, it can be seen that plastic bag has the highest stocking area with 35% while rice bag comes second with 30%, third is foam equipment with 25% and the least area used is plastic equipment with 10% as shown in Figure 14.

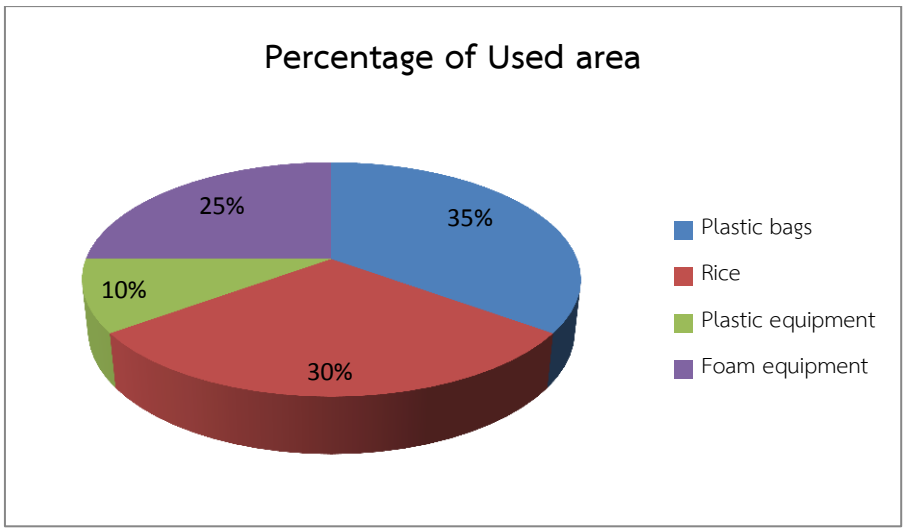


Figure 14: Percentage of Used area

3.3.2 Time of Picking

Picking time of goods has quite an effect on customer satisfaction. Therefore finding of goods' picking time will be another way to check the customer satisfaction. So on this section, data of time picking will further be explained and mentioned.

According to D. Piasecki , in order to make this method effective, the regulation for goods picking from storage must be assigned to worker. Date and time of collecting data must be fixed as well in order to make uniform measurement and avoiding many varied factor caused by various day and time of collection. See Table 13 for more detail of regulation.

And group of worker must have enough skill and knowledge to follow the rules on this experiment. On this experiment there are 4 workers with 3 nationalities. The reason for using this group of worker for analysis is because the data will have less variable factor as well as it can easily be controlled with one specific group of people according to Table 14.

Table 13: Regulation and Reason for using the time picking method

Regulation	Reason
Collect data in each product type	Assign strict picking because limitation of size and weight of goods. Workers use two-wheelbarrow to load and move goods from storage to the shop which cannot load many goods at the same time.
Collect data every Friday for 2 months	The research control all factors affecting to the activity which the result of picking time show in the same range
Period time of collecting data 1. 8.00 – 9.00 2. 9.00 – 10.00 3. 13.00 – 14.00 4. 14.00 – 15.00 5. 15.00 – 16.00	To see whether period of time influence in activity or not
Use same group of workers	To make sure they have the same knowledge and skills

Table 14: Group of worker and their ability that is used in this research

Workers	Nationality	Ability to read Thai	Ability to write Thai	Ability to read and write number	Ability to read and write English alphabet
A	Thai	✓	✓	✓	✓
B	Lao	✓	✓	✓	-
C	Myanmar	-	-	✓	-
D	Myanmar	-	-	✓	-

Remark: Only worker A and B have the additional experiment in the cycle count in accuracy record.

Data of time picking

On this data collection, worker will pick up one type of goods, and the time picking that will be obtained is duration taking for walking back and forth the storage. So after collecting all the time data for each type of goods on each period of time then average time of picking in each type of goods will be obtained. Example of how to collect and calculate the average time of plastic bags is as shown in the Table 15.

Table 15: Example of collected data in plastic bags

Day/Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time
May,9	7.43	9.55	9.39	8.18	10.54	9.02
May,16	8.32	5.43	9.45	7.52	11.19	8.38
May,23	10.38	9.41	11.31	6.22	7.51	9.37
May,30	5.46	8.43	10.11	9.32	9.12	8.49
June,6	5.21	12.39	12.28	7.13	9.49	9.30
June,13	7.34	12.54	11.48	9.39	8.41	10.23
June,20	13.25	9.49	7.31	7.59	5.16	8.56
June,27	7.48	10.31	6.25	7.51	8.04	8.32
						9.36

For the summary table of average time picking for all 4 types of goods shown in Figure 15, the least time taking goods is rice at 5.32 minutes. This is because rice bag has many different colours in packaging which makes it easy to find and take less time to pick up than other goods. Second one is foam equipment at 8.23 minutes in which packaging of foam is transparent or can easily see through for size and type of the product inside. The others are plastic bags and plastic equipment which shows slight different with plastic bag takes a little bit longer than plastic equipment by half a minute. The

reason why plastic bag took the longest time is because there are many brands, types and no clear label. For plastic equipment, labels are not clear as well and arrangement of the equipment is stacked up on the floor which requires long time to look for the wanted products.

Figure 15: Average time of picking goods for 4 types of goods

3.3.3 Accuracy in stock record

This is also an important factor to measure and collect, so it is practical to set up method of collecting data as well in order to make this collection useful with the experiment. According to Brooks and Wilson (2007), it is important to set same collecting day for each week for two months in order to make this data effective and reduce variation from using too many days per week in collecting the data. Each week the data collected will show us deviation among them with 1 items missing is acceptable because total number of goods is less than 100 which makes it impossible to calculate and convert into percentage. Also groups of worker must be in acceptable

standard to be able to assist in this measurement effectively as shown in Table 16.

Table 16: Regulation and Reason for using the accuracy checking method

Regulation	Reason
Collect data in each product type	
Collect data every Sunday for 2 months	Assign cycle count into the research
Collect data of quantity of goods in record and in storage	To see the deviation
1 item missing acceptable	Focus on 1 item missing acceptable because quantity of goods less than 100. Therefore the calculation cannot be in percentage.
Use same group of workers	To make sure they have the same knowledge and skills

Data of stock accuracy

Finding of accuracy percentage can be done by counting on-hand quantity of goods in the storage and comparing with record in stock card with acceptable missing number of 1 unit. From the example table of accuracy in rice record as shown in Table 17, there are 5 acceptable data from overall of 7 brands of rice. Therefore the percentage of accuracy shows is 71.43% for rice. For 2 months period summary of rice measurement is shown that the overall accuracy stands at 67.86% as shown in Table 18.

Table 17: Accuracy checking from types and brands of Rice

Brand	Units (1)	Count quantity (2)	Deviation ABS ((1)-(2))	1 Item missing acceptable
Sticky rice brand Doung-Jai	36	34	2	0
Jasmine rice brand Sam-Ngou	11	11	0	1
Rice brand Mung-Korn	7	8	1	1
Rice brand Hip-po	5	3	2	0
Pink coarse rice	4	3	1	1
Brown coarse rice	5	5	0	1
Jasmine rice brand Dai-No-Sao	63	62	1	1
	131	126		5
			% Accuracy	71.43

Table 18: Two months period of accuracy summary for rice

Date	% Accuracy
May,11	71.43
May,18	71.43
May,25	57.14
June,1	57.14
June,8	71.43
June,15	57.14
June,22	85.71
June,29	71.43
	67.86

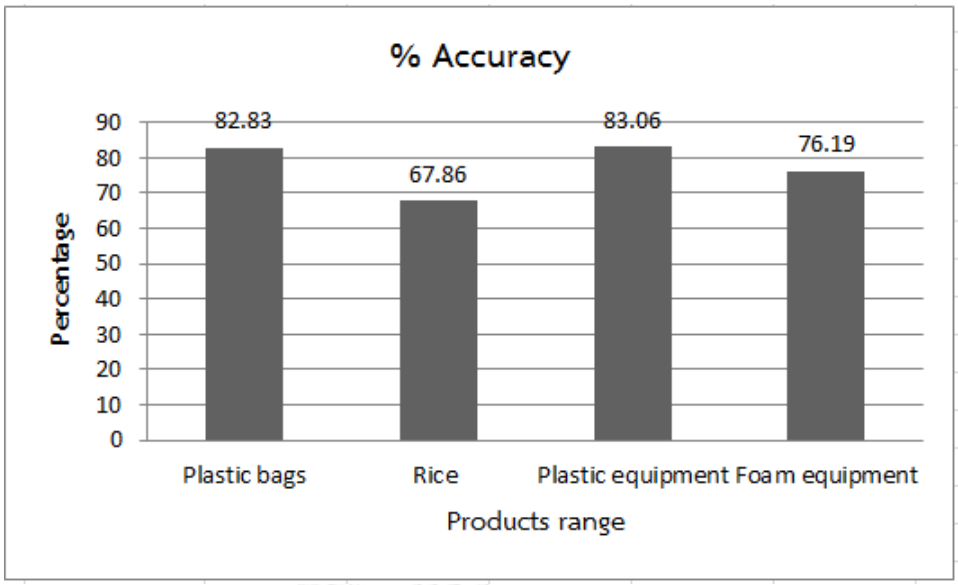


Figure 16: Percentage of accuracy for 4 types of goods

As shown in Figure 16 above, for the overall summary table for all 4 types of goods shows that plastic equipment has the highest accuracy percentage with 83.06% while plastic bag came second with 82.83%. Foam equipment followed on third place with 76.19%. And the least accuracy data is rice with 67.86%. The reason why rice has the least percentage of accuracy was due to 7 types of rice which is a low quantity. So when there is a little mistake, accuracy percentage can highly drop when comparing with other goods like plastic which has up to 83 types of them.

3.3.4 Supplier Limitation and Purchasing Policy

The main reason for understanding the limitation and purchasing policy of suppliers is because the need to make an effective order and make an effective stocking of goods to prevent overuse of space area inside the storage as well as good sequence when to receive and distribute of goods. So there are two main factors that affect the inventory and storage management of the owner which are;

1. Maximum order frequency per month
2. Minimum order required by supplier

So the following table shows the above 2 limitation from all the suppliers of owner's shop.

Table 19: Limitation from suppliers

Product Range	Supplier	Minimum of order size	Maximum of order frequency (times per month)	Lead Time of delivery (day)
Plastic bags	A	10 packs	2	15
	B	30 packs	4	3
	C	30 packs	4	4
	D	30 packs	5	3
Rice	E	20 sacks	4	1
	F	20 sacks	2	1
Plastic equipment	G	30 boxes	4	7
Foam equipment	H	1 truck load	4	3

3.4 Conclusion

From all the studied and collecting data above has implied on how efficient we have managed and make the use of the storage. All 3 pinpointed issues that we have sorted out which are inefficient use of storage, inaccuracy in stock record and low service level in term of time picking goods has also made us aware of the ineffective use and management of storage currently use by the owner. So with the proposing research methodology starting from operational plan and data collection has to be applied in order to improve the issues. All the detail of how the implementation is applied will further be explained on next chapter of Design and Implementation.

Chapter 4: Proposed Method

This chapter shows the research design and implementation. From the problem that occurs in the storage that has been stated in the previous chapter provided that improvement and development of storage need to be in-line with storage management and inventory management. This chapter will be divided into two major subjects as show below.

1) Storage Management
2) Inventory Management

4.1 Storage Management

From the problem analysis in chapter 3 provided that storage management in term of layout of storage, process of storage and policy currently used in storage need improvements. Improvements can be made by following the flow chart shown in Figure 17 starting with categorise of goods by ABC analysis and the frequent of picking to illustrated the importance of each class of goods, whether it is a hot product, or fast moving goods that require the goods to be move swiftly, or it is a slow moving goods that require no special attention. When the goods and their importance have been categorised, products zoning is then used. Zoning should consider the ease of storing and bringing out the goods as well as considering limitation appearance, as different goods have different shape, size and damages that could occur to goods when storing. After the evaluation is done, set of new layout will be used in this study.

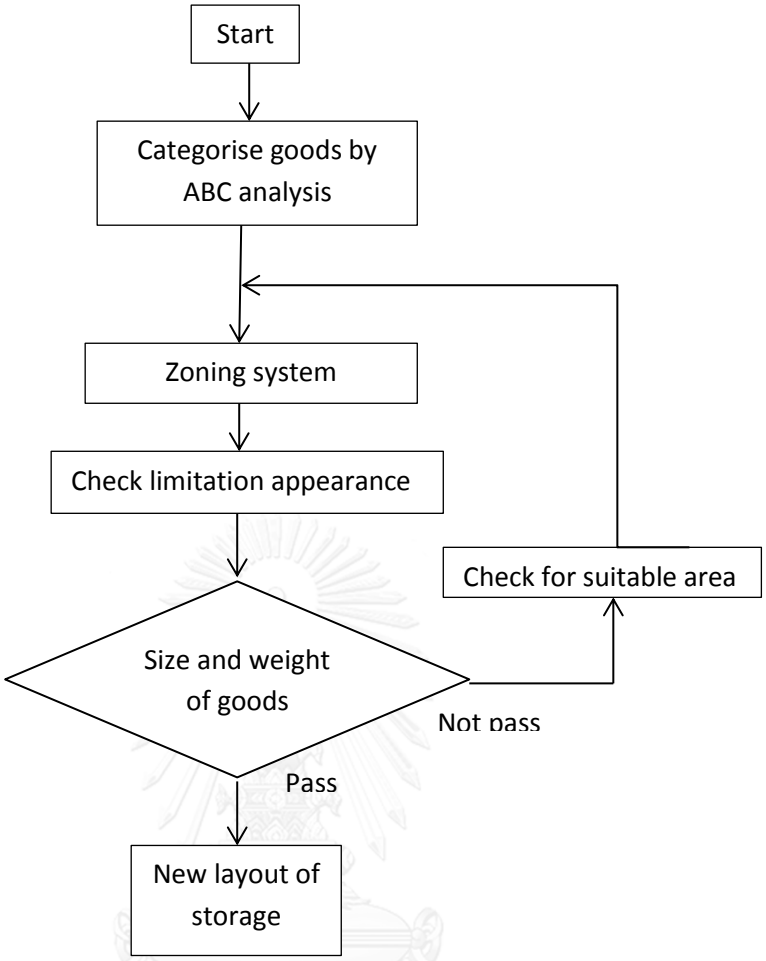


Figure 17: Methodology in layout improvement

4.1.1 Categorise goods by ABC analysis

According to Wild (2002), ABC analysis is a method to categorise the importance of each type of goods using the rule that the least amount of storing goods lead to the highest value. This system considers volume and value of the goods to reduce the attention required and stock counting to control the stock. We cannot prioritize every goods equally as this will used up too much time and assets.

From examining the amount of goods in the storage and their value by categorising, it is clear that plastic bags is the most valuable goods follow by rice, plastic equipment, and foam equipment as shown in Table 20.

Other than the use of ABC analysis for goods categorisation, in order to specify the goods for its importance theoretically and whether or not, it should be provided with a special care, still need to consider for how often each type of goods are picked up leading to the categorisation in goods storage. The parameter use for telling which type of goods has the most frequent pick can be found from selling income of each type of goods in terms of selling unit number, not in terms of value. Goods with high selling unit means that they are frequent pick goods. In this specified theory might not work on every case, but in this case this can be applied in use together with this shop due to the recent start in data collection of sale information and the shop only has 4 main category of goods. That is why it can be considered that which type of goods has the highest selling volume as well as most frequent pick. The goods with the highest selling unit is the plastic bags, while next to come are rice, plastic equipment and foam equipment, respectively.

Table 20: Quantity and value in each product range categorise by ABC analysis

Types of goods	Quantity (%)	Value (Baht)	% of values	% cumulative	Category
Plastic bags	35	675,000	62.65	62.65	A
Rice	30	292,500	27.15	89.80	B
Plastic equipment	10	60,000	5.57	95.36	C
Foam equipment	25	50,000	4.64	100	C
		1,077,500			

Plastic bags are the most valuable product from Table 20 as well as the quantity stored. This contradicts with the theory that product A should be the most valuable but should be least stored. However in this case, we can still categorise plastic bags in group A as plastic bags have many types, herein 83 types when comparing with other goods such as rice, which only has 7 types but rank in the second highest in terms of goods stored and as already mentioned previously that plastic bag has the highest selling unit, when using this information for ABC analysis together with selling unit and how frequent the goods are picked up. These received information are noticeably conformed with each other.

Hence we can conclude that plastics bags are fast moving product which we need to arrange a zone that is easy to put away and picking. Next product is rice, as they are rank second in terms of value we categorise this as medium moving product and plastic and foam equipment is the least valuable goods and low in number of unit sale. Foam equipment also takes up a lot of space, so we categorise plastic and foam equipment as slow moving product, which we can place them in zone which does not need to be frequently visit.

4.1.2 Design new layout

After categorising goods, we know that which goods require special attention, and which goods does not. Product storing should be considered with zoning and the goods limitation.

- Zoning System

According to Tompkins and Smith (1998), zoning by Commodity system is a zoning type that we categorise the type of goods but will not fixed location or fixed area in sub-category like brand or type but goods itself as a whole. For example, plastic bags or rice. According to this research we can categorise into 4 zones. After we have evaluate that zoning will be divided into four zone, we also have to consider whether each zone should store which goods based on limitation appearance of each category. However from the analysis, plastic bags and rice are fast moving products, hence they need to be place where it is convenience to store and pick. Plastic equipment and foam equipment can be store in the back area where it is more difficult to access.

- Limitation of goods

From the limitation of goods Tabled in 11, we consider using shelves and pallets to increase the efficiency in storing goods. We also have to consider the ease of storing and picking out as well as the damage that could occur during the process. Each category required different storing divided into storing on pallets or shelves. Table 21 shows which category is suitable for which type of storage.

Table 21: Table shows suitability for each type of categorised goods

Products range	Pallets	Shelves
Plastic bags	OK but not easy for picking	✓
Rice	✓	Too heavy
Plastic equipment	OK but not easy for picking and have chance for products damage	✓

Products range	Pallets	Shelves
Foam equipment	OK but not necessary because foam is light weight. It can be placed on the top of shelves	✓

From the table it is shown that plastic bags should be store on shelves as they have many brands and sizes, as storing on pallets would be difficult when picking. Rice should be store on pallets as they have clear difference in colour of packaging which can be tell by the eyes so storing on top of each other on pallets won't be any problem. Also they are heavy as well. Plastic equipment are easily damage, they are stored in a box for easy storing as well as convenience in picking, hence they should go on shelves as well as they don’t have to bear the burden weight of other goods. Last item is the foam equipment, which used to store on pallets but storage space is limited as well as foam equipment is a slow moving product and lightweight, it should be placed on top of shelves to utilise space.

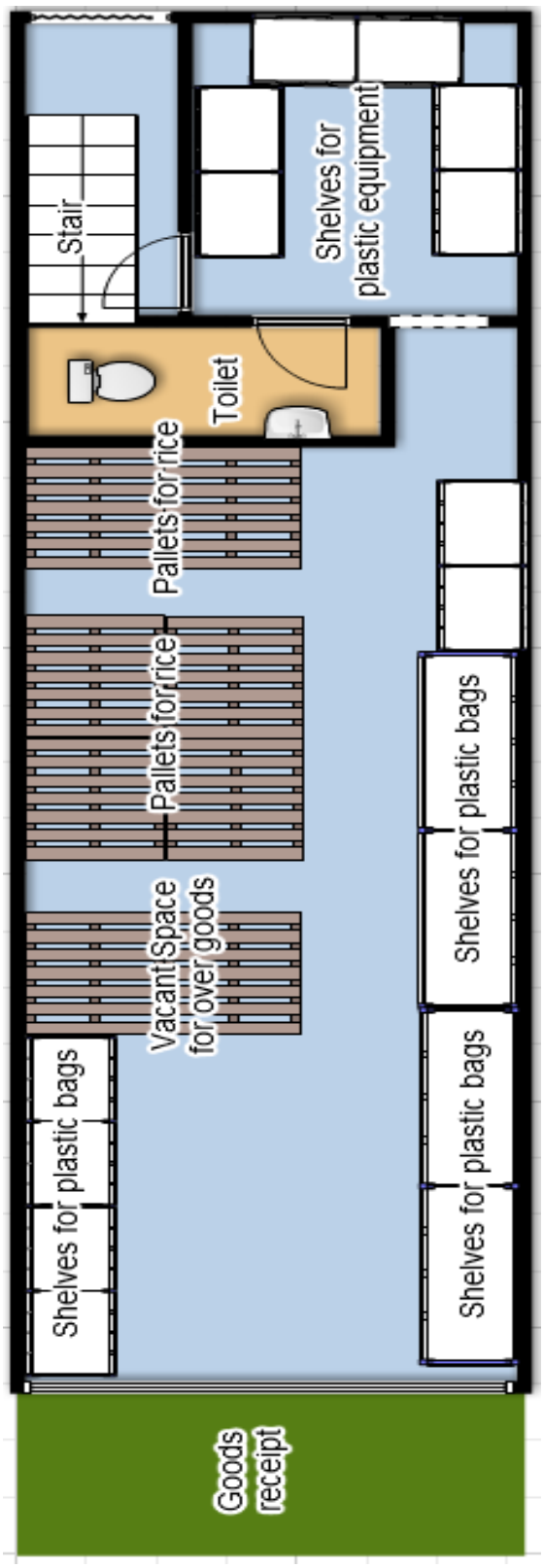


Figure 18: New layout of storage

From Figure 18 can be summarized that the storage of plastic bags will be put on shelves which there are 4 additional put up small shelves to assist in plastic bags storage. This is the first goods that can be seen when entering into storage area. Next is rice which will be put up on pallets with the same amount of existing pallets but there is a rearrangement with addition of aisle for easier access to every rice storage area. And for the innermost part of the storage area, it will be for plastic equipment that has 6 small shelves in order assist in stocking, ordering, convenient to put away and pick up. Lastly, for foam equipment will be stored on top shelves which are an empty space in order to maximise the area usage.

From research and limitations that leads to this new layout, the arrangement is more ordered and increase utilize space making work much more easier and faster.

4.1.3 Set process in storage

Apart from well layout storage, working process in the storage need to be improved in order to enhance storage management efficiency, which is explain in Figure 19.

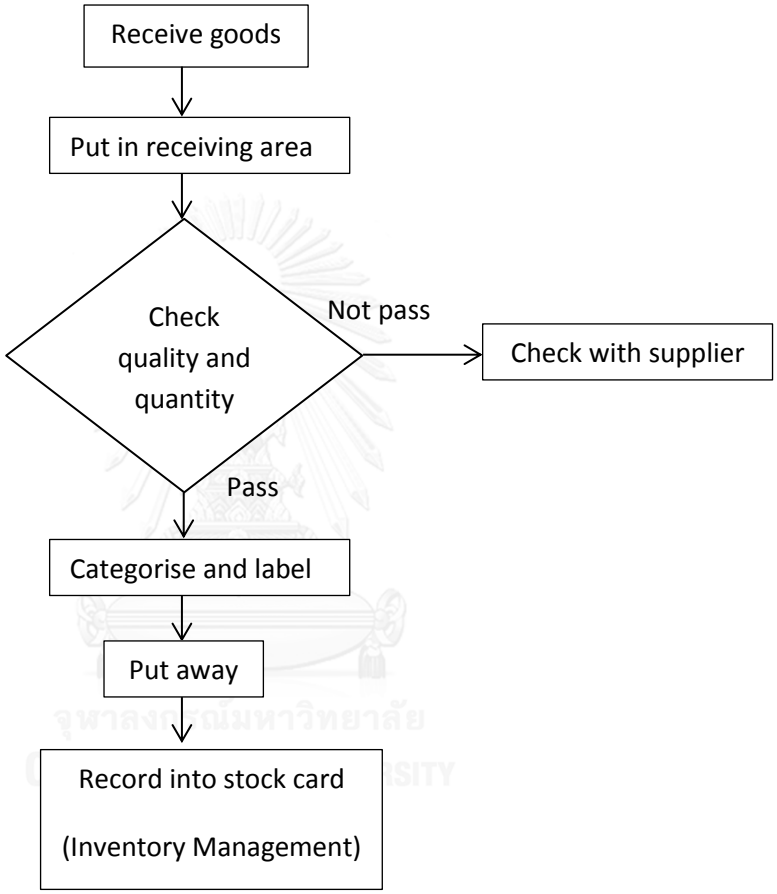


Figure 19: Process in storage

Figure 19 shows process in storage which is one of the policy to enhance storage activity in a more planned manner as activities are explain below.

- Receive goods

When receiving goods from suppliers, workers will place all the goods that required storing in the receiving area in front of storage. By placing them in receiving area, goods checking process is more convenience and accurate from zoning process for receiving process.

- Identify and sort goods

After receiving goods from suppliers, verifying process would be done by categorising goods and check quality and quantity of goods to ensure that this match the order. If the process is done and there is no problem, workers then proceeds to storing goods, however if there is an incorrect in quantity or defect due to transportation, shop will contact supplier for replacement.

- Put away goods

Storing goods can be done by following 3 steps below

1. *Put away by Commodity System*

From the studied of Tompkins and Smith (1998), we choose to put away and storage goods by Commodity System as the system is suitable for our storage. Workers need to categorise the goods so that it is convenient to put away. Categorising goods can be done by brand and type for example, plastic bags sizes; plastic bags size 6x9 (cm) of 10 packs or plastic bags size 7x11 (cm) of 5 packs so that the same type of goods will be place in the same area, however there would be no fixed area for the goods, only brief designated area of plastic bags and brand of those types of goods.

2. *Tag and Label policy*

After sorting out the goods, workers needs to label the product by type of goods such as PP 6x9, PE 5x8, or PE 6x9 and label date of receiving goods also to shows which goods come in first.

3. *First In First Out*

After labelling of goods, storing the goods need to consider First In First Out (FIFO) system also, by seeing the date of receiving goods label so that older goods can be sold first and newer goods would be sold later to avoid deterioration of goods from stocking too long, for example rice, if store for too long weevil will occur hence older goods need to be bring out first before storing newer goods on the inside. In this case, there is a limited area for goods storage, in order to do lot splitting for storage of goods for example; splitting plastic bags lot into ordering round can be difficult because there is an area loss in storage. Therefore what can be done is inventory management which will be stated on the next part. But for rice can be split into lot due to there are only 7 types of rice, and order is made only on 2 suppliers with first sell is made on first order that come, order that come after will be sold later. But nevertheless, it still cannot be concluded due to consideration of stocking volume of rice that must be made as well.

- Picking goods

Picking goods is another important process in storage policy because in this research storage management evaluation efficiency depends on time of picking by discreet or strict picking system D. Piasecki . As picking in the

storage is done by workers, no equipment or machine to help, as well as the goods in the storage is heavy; workers won't be able to pick different goods at the same time, for example, lifting 1 sack of rice (50 kg) or 1 pack of plastic bags (30 kg). They also have to consider FIFO system as well.

4.1.4 Set workers policy

Workers policy is a basic rule to guide the workers with systematic understanding to storage process.

1) Workers need to comply with the process in storage stated above.
2) Workers need to consider hygiene and safety in the storage, workers need to sweep the aisle in the storage daily and keep storage clean. When workers use the toilet in the storage, they need to clean and always close the door after use, as there are consumable goods in the storage such as rice. Hygiene is very important to prevent pest from causing damage to goods.

Above policy would help align the process to ensure efficient usage of storage as well as reduce risk in damage goods in the storage as well.

From above, storage management starts with arranging new layout, set process in storage and set workers policy to manage work force to ensure policy is being follow to maximize benefit as well as imposing order in the storage.

4.2 Inventory Management

After storage management, inventory management is required to maximize storage efficiency. The efficiency of storage is determined by the amount of goods stored. The amount of good stored can be divided into two factors as purchasing from suppliers and customers demand. Customer demand cannot be exact, however we can estimate this, as for purchasing from suppliers, the shop can set the policy to control purchasing activity to maximize storage efficiency. We cannot control customer demand, hence we will focus on managing purchasing order with suppliers and set the policy to control inventory. Record should be made when purchase came in by using stock card. A good stock card system will show how much goods are in-hand. A good information filing will reflect in record accuracy between actual goods in stock and numbers recorded. Inventory management link to storage improvement as the stored goods utilize the space in the storage as well as stock card and inventory accuracy is the key performance index in storage management.

In inventory management we will touch on set purchasing policy, design formal form of stock card, set stock card policy, and set checking policy to improve storage management and development.

4.2.1 Set purchasing policy

Before setting purchasing policy, study should be made on the problem or effect of purchasing first by root cause analysis by fishbone diagram. Problem or effect of purchasing is illustrate in Figure 20.

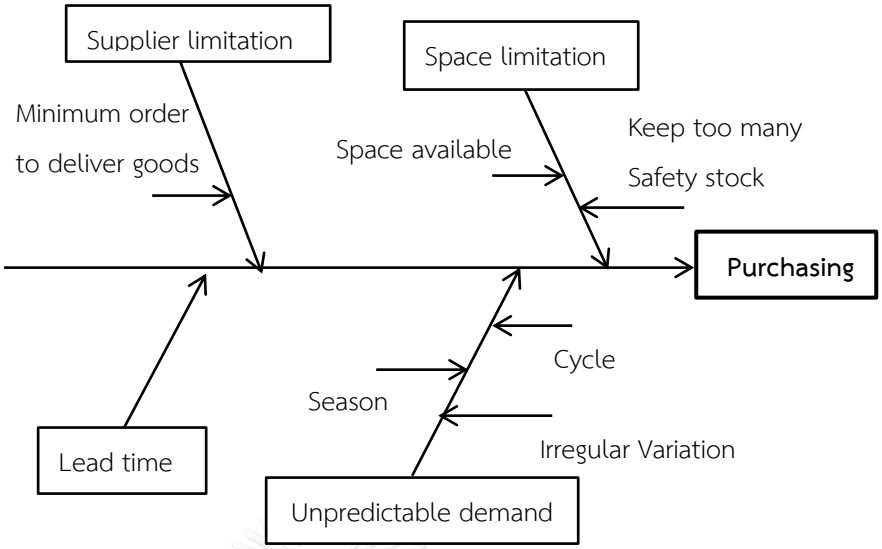


Figure 20: Fishbone diagram for purchasing

Figure 20 show the factors that affect purchasing of goods by divided into 4 main points as suppliers' limitation, lead time, space limitation, and unpredictable demand. From 4 points above can be segmented into three subjects below

1) Problem from suppliers – This subject group all suppliers' limitation whether it is minimum order, lead time, or frequency of order which are the requirements from the suppliers. In some limitation from suppliers, shops cannot order small quantity but frequently to reduce stock holding as it is a limitation from supplier. This is one key factor in purchasing.
2) Problems from storage – From lacking of good management system, storage cannot contain large amount of purchase goods. Speculation and hoarding to gain profit will be difficult to do as well as ordering to demand won't be possible as too much space

is wasted on storing slow moving goods. Hence when purchasing, available space in storage need to be considered.

3) Problem from unpredictable demand –This problem occur from the unpredictable demand from customer which may have high demand, leading to shortage of goods or low demand which leads to high stock. Ordering to demand is not always easy.

After the study of problems and effect to purchasing, we established that we can solve the suppliers' limitation and storage problems. Problem from storage management has been described in topic 4.1 hence we will focus on problem from suppliers' limitation improvement. According to Stevenson (2001), there are 2 purchasing system being Fixed – Time Period Ordering System and Fixed – Order Quantity System.

Fixed – Time Period Ordering System is a system of purchasing that fix date and cycle consistently for example ordering every 7 days where quantity varied depending on stock, as explained in Figure 21.

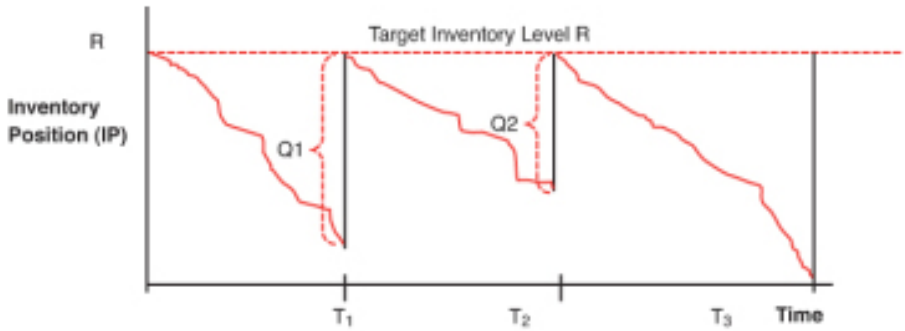


Figure 21: Fixed – Time Period Ordering System

According to Wild (2002), Fixed – Order Quantity System is a system in which the quantity is consistent while ordering will occur when goods reach to reorder point. This model has an advantage of that the shop can order whenever we want. We can set target point as low as we want to reduce inventory carrying cost by ordering small amount, frequently, and when the goods reach reorder point, shops can order goods without fix time of order as shown in Figure 22.

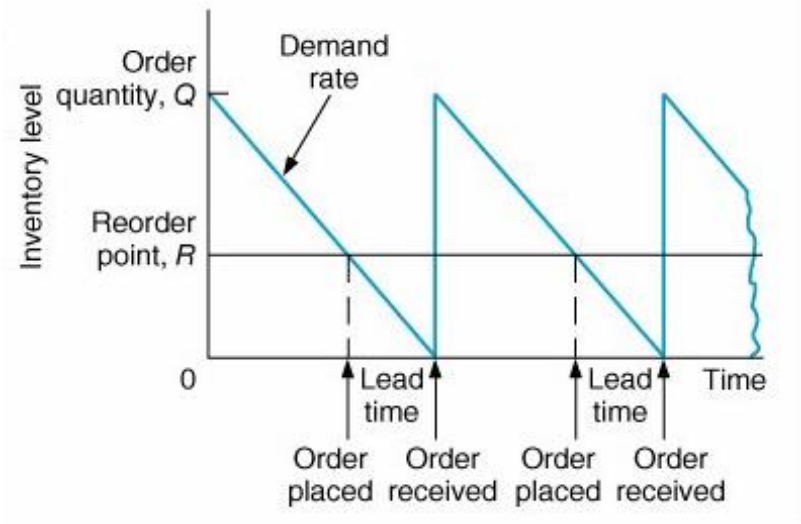


Figure 22: Fixed – Order Quantity System

From both systems, Fixed – Order Quantity System is a system which should be develops to use which benefit the shop the most, however in reality, there limitation from suppliers. Suppliers' limitation main concern is cost of delivery. The optimal point between suppliers and our company would be best however, Economic Order Quantity (EOQ) need to be study first as well as limitation from suppliers as illustrate in Figure 23 and Table 22.

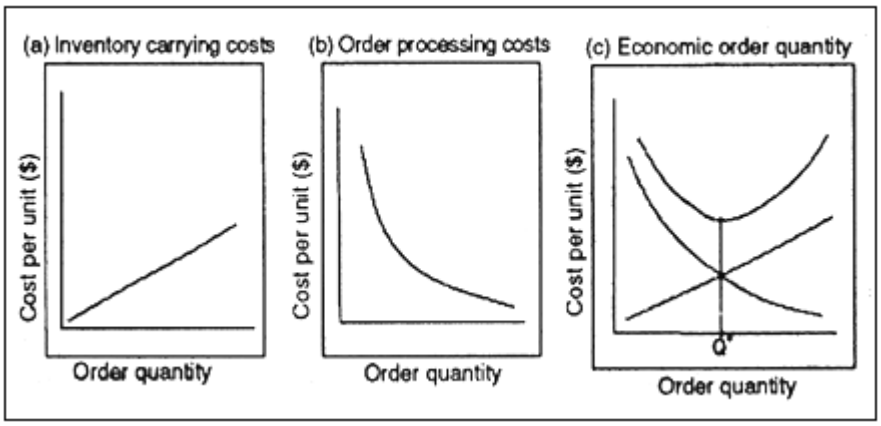


Figure 23: Economic Order Quantity System

Figure 23 shows optimal point between inventory carrying costs and order processing costs from (a) it can be shown that if purchase goods is high, carrying cost is also high as well, but if order large quantity at once, number of order would be less (b) making low order processing cost, hence, the optimal point (c) of both suppliers and our shop which won't accrued additional cost would benefit both sides Schwarz (2008).

Table 22: limitation from suppliers

Supplier limitation	limitation
Minimum of order	Supplier will not deliver goods in case of the shop order in smaller number than limitation
Frequency of goods delivery per month	Supplier limit the time of delivery such as Supplier E will only deliver goods maximum 4 times per month. Therefore the shop cannot order in small quantity and frequently as wanted. If the shop want goods to be deliver more than 4 times, the cost of delivering will be charge.

From Table 22 as suppliers' limitation are shown, the best purchasing policy would be the combination of the advantages from Fixed – Time Period

Ordering System and Fixed Order Quantity System which can be shown in flow chart in Figure 24.

Purchasing policy is set by Fixed – Time Period Ordering System monthly due to the frequency limitation in goods delivery from suppliers. If the shop orders frequency exceed suppliers' limit there would be additional delivering cost. To save cost, the number of order per month has to be within limit. On the other hand, when demand is abnormally high, goods would face shortage or the reach to reorder point has been met, shop can still order additional goods without worrying about cycle time of next order. In this case, customer demand is the key. It can be conclude that this system combines the advantages from Fixed – Time Period Ordering System and Fixed – Order Quantity System to maximize flexibility and benefits.

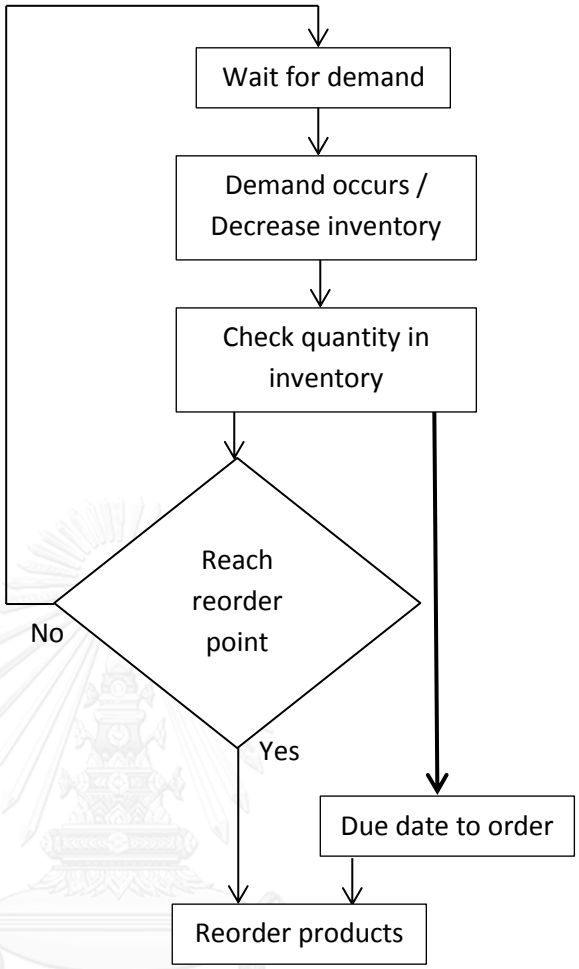


Figure 24: Purchasing policy

From studies, the information and knowledge can be tabled into purchasing policy as Table 23.

Table 23: Table representing frequency of order in each month

Product Range	Supplier	Limitation of order size	Limitation of order frequency (times per month)	Order size	Order frequency (times per month)	New order frequency (times per month)
Plastic bags	A	10 packs	2	50 packs	1	2
	B	30 packs	4	50 packs	2	3
	C	30 packs	4	40 packs	2	2
	D	30 packs	5	70 packs	4	5
Rice	E	20 sacks	4	50 sacks	3	4
	F	20 sacks	2	60 sacks	1	2
Plastic equipment	G	30 boxes	4	40 boxes	3	3
Foam equipment	H	1 truck load	4	1 truck load	3	2
					19	23

From Table 23 it is clear that, the number of order has increase, while order size has decrease whilst reducing inventory carrying cost. In plastic bags segment it can be seen that for suppliers A and D, shop order maximum limit number of orders while for B and C this is not possible as there is limitation of order size from suppliers. As there is an increase in goods order round, volume will be decreased. But at present order volume is already little. If there is an addition of order round, there is a high chance that order size will not meet the minimum order according to suppliers' condition. As for rice and plastic equipment, the order frequency has been set to maximum frequency of order allowed, but for Foam equipment the number of order has been reduced from the problem mentioned in 3.1.1 from the voice of

owner that foam equipment has a drop in demand. Reducing the quantity per order is not possible as the minimum order has been reached; hence the number of order monthly has been reduced.

After the limit has been set for ordering for each supplier, purchasing policy can then be set up whether which is the best date to order from which supplier for convenience and mutual understanding by fixed day to order as Table 24.

Table 24: Policy of date ordering in each supplier

Products Range	Supplier	Lead time of Delivery (day)	Order size / Lots size	Order frequency (times per month)	Cycle Time (day)	Fixed Time Ordering System
Plastic bags	A	15	30 packs	2	15	1st, 15th
	B	3	35 packs	3	10	10th, 20th, 30th
	C	4	40 packs	2	15	2nd, 16th
	D	3	55 packs	5	6	2nd, 8th, 14th, 20th, 26th
Rice	E	1	35 sacks	4	7	1st, 8th, 15th, 22th
	F	1	30 sacks	2	15	3rd, 17th
Plastic equipment	G	7	40 boxes	3	10	9th, 19th, 29th
Foam equipment	H	3	1 truck load	2	15	4th, 18th

From Table 24, Schedule can be set as Figure 25 below. Table 24 detailed purchasing date for each supplier in a monthly basis, for example the shop will order from supplier A on 1st and 15th as below table. If the order date falls onto Sunday, which is suppliers' holiday, one who make the order have to order goods on Saturday. In February order those falls on 29 and 30 need to be done on the 28th.

1	2	3	4	5	6	7	8	9	10
A	C	F	H				D	G	B
E	D						E		
11	12	13	14	15	16	17	18	19	20
			D	A	C	F	H	G	B
				E					D
21	22	23	24	25	26	27	28	29	30
	E				D			G	B

Figure 25: Schedule of purchasing in a month

After the schedule has been set for purchasing, the next consideration is the quantity of goods required for each order. Quantity should be enough for demand but should not raise the inventory carrying cost too high. Apart from inventory carrying cost, storage space is also another factor to consider, as spaces are limited. Ordering as close as possible to customer demand will benefit the shop the most. Thus, the shop will simulate storage management using Minimum Order Quantity (MOQ) system. This system calculates the order quantity from target point then deducting on-hand inventory Stevenson (2005). Target point depends on two factors, first; when ordering goods, shop must reach supplier limitation, second; order must meet customer demand by using demand forecast. Another important factor is that the shop must consider minimum stock or reorder point to prevent shortage.

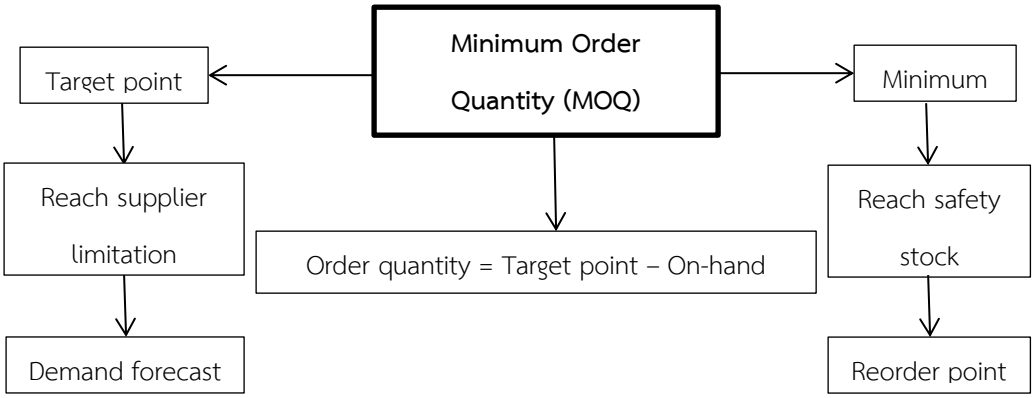


Figure 26: Minimum Order Quantity System (MOQ)

To determine Target point or Minimum point, the only key point that can be used to determine the storing goods is demand. Calculated demand and the standard deviation of each day can help forecast the required goods per day. After lead time and cycle time is factor in, we can calculate how much quantity we need to order per purchasing.

Demand (ḋ)

Demand can be calculated from historical sale volume. To be able to forecast accurately, the historical data need to be at least 3 consecutive years Apiprushchayasakoun (2011), however the shop has been collecting data for 2 years hence the accuracy may not be accurate. On the other hand, when looking at the data closely in the past two years, the month to month changes very little hence the shop is calculating the simple average demand but will use standard deviation to improve accuracy as well.

Table 25: Example of average demand of Sticky rice brand Doung-Jai (One of goods in supplier E)

	Sale volume (50 kg/pack)		Average sale volume per month	Average sale volume per day
	2012	2013		
January	76	82	79.0	2.633
February	82	86	84.0	2.800
March	89	84	86.5	2.883
April	74	76	75.0	2.500
May	78	75	76.5	2.550
June	69	81	75.0	2.500
July	83	87	85.0	2.833
August	93	94	93.5	3.117
September	93	90	91.5	3.050
October	77	85	81.0	2.700
November	83	87	85.0	2.833
December	92	98	95.0	3.167
Sum	989	1025		
Average	82.417	85.417	83.917	$\bar{d}$ = 2.797

From Table 25, the number of average demand per month can be found for each month then calculated the number in each month divided by 30 to be average demand per day. The table is the example of average demands of sticky rice brand Doung-Jai which one of goods in supplier E.

Standard Deviation (σ)

According to Kalla (2009), standard deviation can be calculated from the formula below

$$\sigma = \sqrt{\frac{\sum(d-\bar{d})^2}{N}}$$

where d = Average demand per day in each month

$\bar{d}$ = Average demand per day in year

N = 12 (12 months period)

Table 26: Example of standard deviation of Sticky rice brand Doung-Jai (One of goods in supplier E)

	Average demand per day (d)	$(d - \bar{d})$	$(d - \bar{d})^2$
January	2.633	-0.164	0.027
February	2.800	0.003	0.000
March	2.883	0.086	0.007
April	2.500	-0.297	0.088
May	2.550	-0.247	0.061
June	2.500	-0.297	0.088
July	2.833	0.036	0.001
August	3.117	0.320	0.102
September	3.050	0.253	0.064
October	2.700	-0.097	0.009
November	2.833	0.036	0.001
December	3.167	0.370	0.137
Average	$\bar{d}$ = 2.797		
Sum			0.587

From Table 26 it can be seen that đ value of sticky rice is equal to 2.797 and when it is substitute into standard deviation formula, the standard deviation would be 0.221. After obtaining standard deviation it is then used to calculate daily safety stock.

Safety stock (SS)

According to Stevenson (2005), Safety stock is the inventory that held by company in purpose to prevent the shortage in supply of goods to the customers while also use as a buffer when there is an error from demand forecast or suppliers have late in their delivery. In order to find appropriate amount of safety stock, standard normal distribution is introduced for calculating more precise safety stock as the variation that regularly happen in factory scale is commonly occur in normal distribution form. The formula of safety stock is show in formula below. The "z" value is obtained from determining the probability that allow the shortage in supply to happen and use that particular opportunity to find "z" value from the table in Appendix D. For instance, if there are 10 orders has been placed, only 1 time is allowed to have a shortage which means the probability of shortage is 0.1 (or 10 percent), and the cycle service level is 90 percent, so the "z" value that obtain from the table is equal to 1.28.

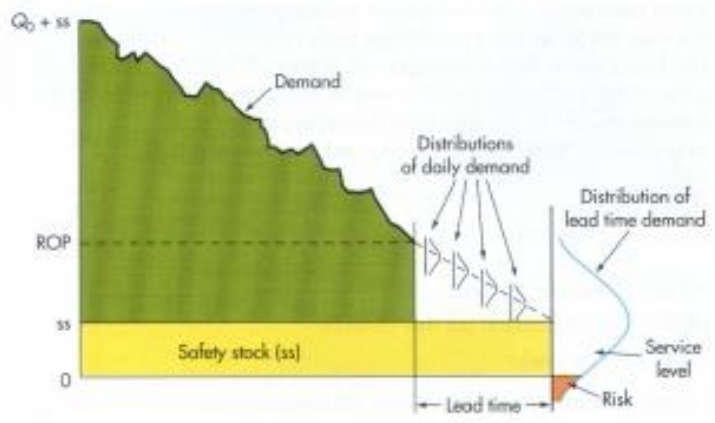


Figure 27: Finding of safety stock by applying the standard normal distribution

After z can be found from z table then substitute into safety stock formula below

$$\text{Safety stock} = z\sigma$$

As the example of sticky rice, safety stock can be calculated by substitute z as 1.28 and standard deviation as 0.221 into formula. Then the safety stock of sticky rice for one day is equal to 0.283.

Target point

When the demand of the customers and the deviation that could possibly happen in one day can be estimated, then these will use to combine with purchasing policy that has been specified about the purchasing date, lead time and cycle time in order to find the “target point” that will be used to stock the goods. According to Stevenson (2005), target point is the maximum amount of goods that can meet with the customers’ demand in one-time order which can be calculated by using the following apply formula.

$$\text{Target point} = \bar{d}(L+T) + SS$$

where $\bar{d}$ = Average demand per day

SS = Safety stock = $z\sigma$

L = Lead time (day)

T = Cycle time (day)

Therefore instead of the equation, target point of Supplier E can be found as shown in Table 27 below

Table 27: Target point of Supplier E

Supplier E	Demand per day **($\bar{d}$)**	Lead Time (day) **(L)**	Cycle Time (day) **(T)**	Safety stock **(SS)**	Target Point	**Target Point (sacks)**
Sticky rice brand Doung-Jai	2.797	1	7	0.283	22.66	23
Jasmine rice brand Sam-Ngou	0.649	1	7	0.160	5.35	6
Rice brand Mung-Korn	0.369	1	7	0.116	3.07	4
Rice brand Hip-po	0.250	1	7	0.075	2.08	3
Pink coarse rice	0.117	1	7	0.039	0.98	1
Total						37

Reorder point

According to Arrand (2008) and Slater (2010), reorder point is determined with purpose to use in case of irregular demand (demand significantly ramped up) has contributed the shortage in supply sooner than the upcoming ordering period as the goods have been sold exceeding the amount of the goods that have been stored in the inventory. Accordingly,

there shall be a certain amount of goods to support the customers' demand in the meantime that the supplier is processing to deliver the goods to the company. The reorder point can be determined from the following formula.

$$\text{Reorder point} = (\bar{d} \times L) + SS$$

where $\bar{d}$ = Average demand per day

SS = Safety stock = $z\sigma$

L = Lead time (day)

Therefore instead of the equation, reorder point of Supplier E can be found as shown in Table 28 below

Table 28: Reorder point of supplier E

Supplier E	Demand per day **($\bar{d}$)**	Lead time (day) **(L)**	Safety stock **(SS)**	Minimum stock / Reorder point	**Minimum stock / Reorder point (sacks)**
Sticky rice brand Doung-Jai	2.797	1	0.283	3.08	4
Jasmine rice brand Sam-Ngou	0.649	1	0.160	0.81	1
Rice brand Mung-Korn	0.369	1	0.116	0.49	1
Rice brand Hip-po	0.250	1	0.075	0.33	1
Pink coarse rice	0.117	1	0.039	0.16	1
Total					8

Order Quantity

With regards to the purchasing policy that has been specified since the beginning that the purchasing order will be processed by using Fixed-Time Period Ordering system. This system will specifically fix the period of placing the purchasing order but the amount of that particular order can be varied. The order quantity can be defined from the following formula Stevenson (2005).

Order quantity = Target point – On-hand inventory

Because of the amount of finished goods that have been sold is fluctuated, so the remaining stocks in the inventory also vary in every purchasing order. Consequently, the order quantity of any particular purchasing order is also changed.

Special Case

As mentioned previously that the Fixed-Time Period Ordering system has been specifically defined as the primary purchasing policy. However, in case of irregular demand is happening, and the purchasing order have to be placed in prior of the ordering period, so the cycle time need to be changed. The change of the cycle time in this case can be explained by using this following example. The Table 24 is an example of the ordering period for Supplier E which the purchasing order will be placed to Supplier E in every 1, 8, 15 and 22 of every month, so the cycle time in this case is 7 days and 1 day for lead time. However, when the customers' demand ramped up sooner than usual, the purchasing order need to be placed to Supplier E in advance of ordering period. For instance, in case of the stock has reached the ordering

point in 5 Jan, the goods will be delivered in 6 Jan (1 day lead time) but the ordering period has been specified that the purchasing order shall be placed in 8 Jan. If the purchasing order has been placed to Supplier E again on 8 Jan (after placed on 5 Jan), the quantity of order might not meet minimum order quantity of Supplier E. Moreover, place order again on 8 Jan might also exceed the maximum frequency of order in a month which is limited from supplier E. The additional cost has to be paid by the purchaser if purchasing orders have been placed more than maximum frequency that allow the order to be placed with the price in quotation. Accordingly, the alternate option is to skip the order on 8 Jan and increase the quantity of the goods that has been ordered since 5 Jan to cover the customers' demands until 15 Jan as demonstrates in Figure 28.

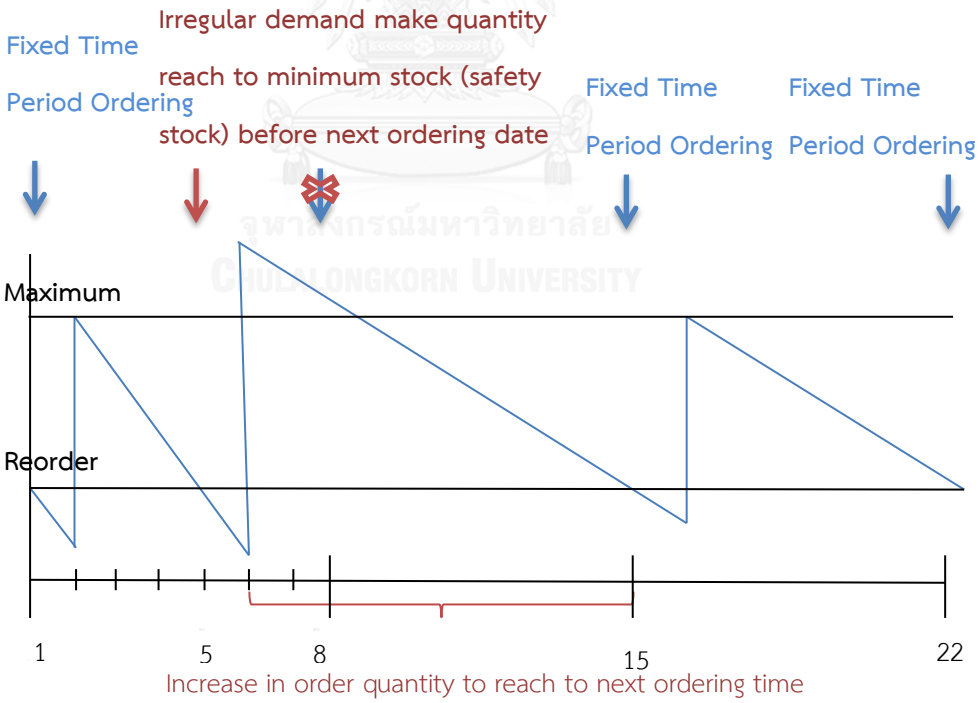


Figure 28: Chart of purchasing policy in case of skipping the next order

Although, in case of the reorder point is quite earlier and has a large gap if skip the upcoming order period which needs to order the goods in very large quantity and might not have enough space in inventory to stock the goods. In such case, the frequency of placing order need to be exceeded (additional cost might need to be paid) and the order quantity has to reach minimum order quantity as demonstrates in Figure 29.

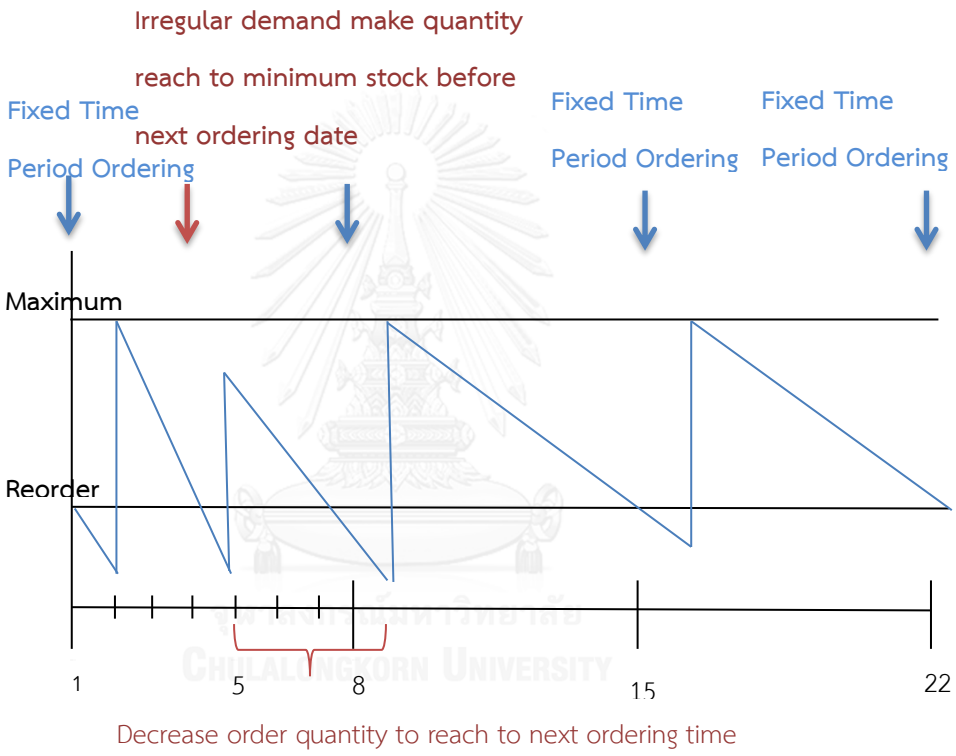


Figure 29: Chart of purchasing policy in case of increasing order frequency

The cases that have mention previously are the special and not commonly happen. However, the decision on the option has to be carefully considered by choosing the best option that contributes the most benefits. These special situations is unpredictable and can't be anticipated but in this research has provided the practice that can be adapted according to the situation. The purchasing policies that have been specified is not the fixed

formula but can be altered by considering the current situation and what would be the best options for the both sides to have flexibility in their operation.

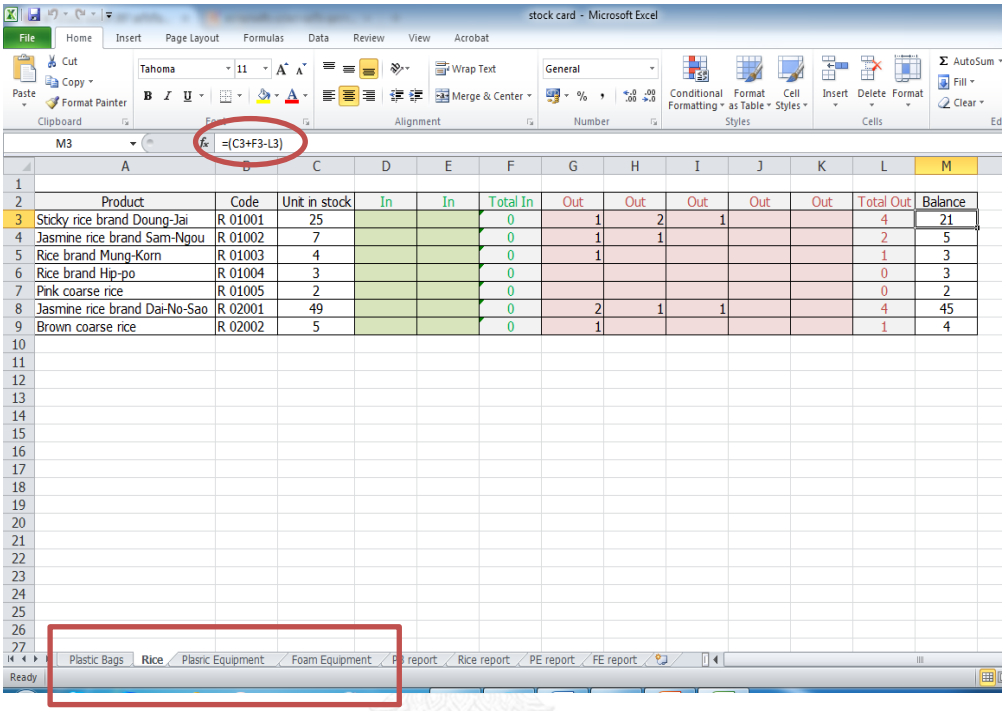
4.2.2 Create form of stock card and set stock card policy

Maintaining a complete stock record is a good storage management practice, where the recorded data can clearly show the actual amount of goods in the stock. These recorded data can be used as a resupply indicator and weekly cycle count inspection.

Form of stock card

Since the shop just recently start collecting stock records, the standard record procedures, as mentioned in Chapter 3, was not yet fully implemented. A spread sheet software package, Microsoft Excel, will be used to assist in keeping record archive. Due to its ease of use, Microsoft Excel was selected as a main application for keeping stock card record. Then workers will be trained to use the stock card in the correctly way in order to prevent a human error.

The stock card form can be done by using Microsoft Excel as shown in Figure 30 below:



	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2	Product	Code	Unit in stock	In	In	Total In	Out	Out	Out	Out	Out	Total Out	Balance
3	Sticky rice brand Doung-Jai	R 01001	25			0	1	2	1			4	21
4	Jasmine rice brand Sam-Ngou	R 01002	7			0	1	1				2	5
5	Rice brand Mung-Korn	R 01003	4			0	1					1	3
6	Rice brand Hip-po	R 01004	3			0						0	3
7	Pink coarse rice	R 01005	2			0						0	2
8	Jasmine rice brand Dai-No-Sao	R 02001	49			0	2	1	1			4	45
9	Brown coarse rice	R 02002	5			0	1					1	4

Figure 30: Formal form of stock card

As shown in the Figure 30, goods will be divided into their respective categories, where a sheet represents a good category. The green columns represent incoming goods from suppliers, whereas the red columns represent the outgoing goods to sell to the customers. According to the predetermined purchasing policy, each stock card table is designed to be used for one week. Adjustment will be done during the weekly check. Note that there is only two incoming columns, since weekly resupply cycle is at most twice per week. At most five outgoing of picking times are allowed per week but in case of workers bring out goods more than five, they might add up the number before put into the stock card. Total in and out will be an automatic

summation of incoming and outgoing goods per week. Balance is then calculated by:

Balance = Stock + Total Incoming – Total Outgoing

In addition, daily report that shown the number of incoming and outgoing goods is also computed from the balance field. Minimum order or reorder point in the daily summary is as shown in Figure 31. Workers are responsible only to put the correct number in and check whether the quantity of goods reach to reorder point or not.

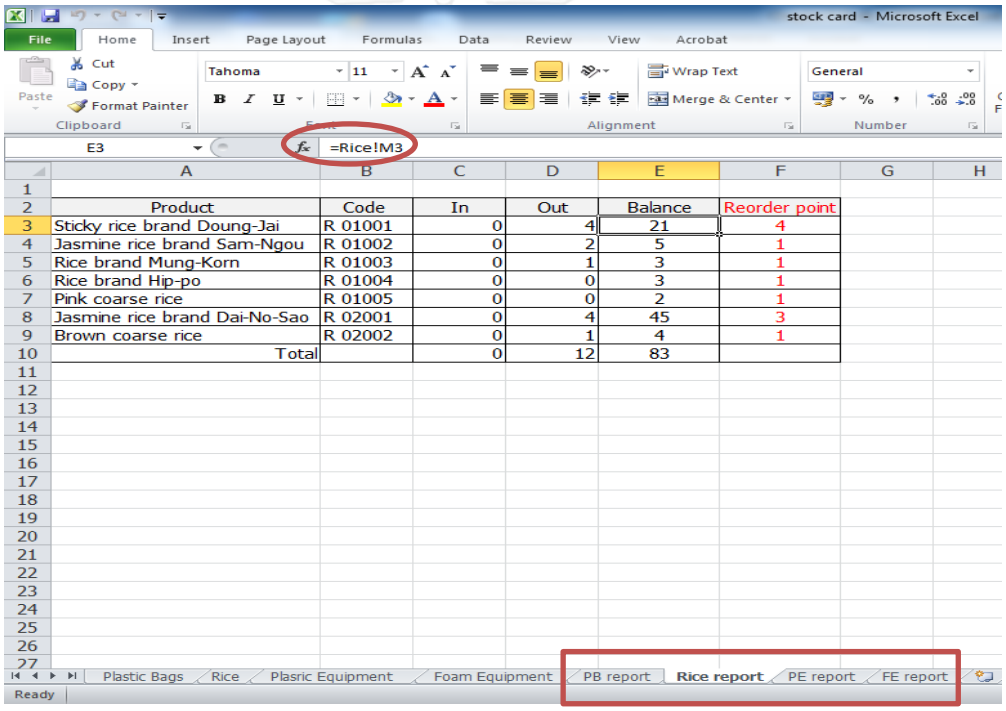


Figure 31: Daily report link from Stock card

Stock card policy

Stock card policy was established as a guideline to ensure that the stock card record is consistency entered correctly. Responsible staffs must always lodge a record immediately after both receiving and picking out goods. At every evening, the daily report must be printed, and the goods quantities must be checked, in order to look for goods that already reached reorder point. Possible errors that might occur are mostly going to be human error. Thus, employee trainings regarding stock card policy is highly recommended.

4.2.3 Create form of accuracy report and set stock checking policy

Concurrently with the stock tracking system, a record quality tracking system is also required in order to quantify the workers' performance. Weekly cycle count will check both the actual number of remaining goods and the recorded quantity from the stock card Brooks and Wilson (2007).

Form of accuracy report

The cycle count accuracy form has its simplicity design to promote ease of use, as shown below in Figure 32.

Cycle Count Accuracy Report

Date : ..... Prepared By: .....

Item	Unit	Count quantity	Deviation
ถุงเย็น PE กุญแจ			
4 x 6			
5 x 8			
6 x 9			
7 x 11			
8 x 12			
9 x 14			
10 x 15			
12 x 18			
14 x 22			
16 x 26			
20 x 30			
30 x 50			

Figure 32: Cycle count sheet

Checking policy

Checking policy is simply a cycle count that performed on every Sunday. The two inspectors will lodge their name and inspection date in the form before commencing the weekly inspection routine. One of the inspectors will count the physical goods, whereas the other will record the result. Using two inspectors can significantly boost the inspection accuracy. Inspection routine will check all goods by their categorise in the following order of importance that had been done by ABC analysis as: 1) plastic bags, 2) rice, 3) plastic equipment, and 4) foam equipment. Additionally, random periodic check will also be carried out once in three months.

From above, inventory management starts with set the purchasing policy to control quantity of goods to be kept in storage then crate stock card and checking system to give an accurate record for the shop. All these lead to better in inventory arrangement.

4.3 Conclusion in research design and implementation

In this chapter, the enhancement plans for storage and inventory are discussed. Both proposed storage and inventory improvement plans and policies were successfully implemented.

For inventory when setting purchasing policy, for example in supplier E would be applied for use with other 7 suppliers that the shop has done contract with them. This is in order to have same discipline and follow the policy with similar way in every supplier to make the most use of the storage area as well as goods management process and process in storage from the above mentioned policy.

From the improvements, the most changed that can be seen is the new layout. New layout meets all requirements which are the amount of capacity that has more space for goods and also the orderly in keeping goods. Process and policies are set in order to force the workers to follow and obey systematically and correctly which will surely make the outcome most useful to the storage.

Results from this implementation, which will be discussed in the following chapter, were quantifiable after the shop had successfully enforced the suggested policies.

Chapter 5: Evaluation and Conclusion

As previously discussed in Chapter 4, the goods storage process was enhanced by altering the storage methods and policies. In order to access the impact of these changes, data must be collected similarly as the data collecting procedure before the storage improvement, which is discussed in Chapter 3. Data Collection need to have the set-up of method, time period of collection and sample group that will be gathered in the same set of data in order to have clear information of what is affected from the change of data. In this chapter, the collected data after the implementation of storage improvement will be discussed.

The following criteria will be discussed as followed:

1) Layout comparison
2) Capacity of goods
3) Time of picking
4) Accuracy in stock record

Overall result based on these criteria will then be further discussed to illustrate the improvement of the shop.

5.1 Layout comparison

The most obvious change that can be immediately notice is the layout alteration. When arranging the storage layout, the following key points should be taken into consideration: goods usage frequency, ease of access, and distinct characteristic of each good when stowed. Shelves and pallets can also enhance the storage space utilization. Figure 34 illustrates the changes between the original and the new layout. With a limited storage spaces and variety of goods, it is necessary to optimize the storage space. It can be seen from Figure 34 that the number of plastic

bags and plastic equipment storage shelves were increased. 4 small shelves were added for supporting plastic bags storage while another 6 small shelves were for plastic equipment storage. According to the categorisation of goods by ABC analysis and how frequent the goods are picked up, it is suggested that the plastic equipment should be stored at the back portion of the storage area, since plastic equipment are slow moving product. Plastic bags were also arranged by brand and type for further ease of access and plastic bag is the first goods found when entering into storage area. The number of pallets was also reduced from 12 to 6. This is due to the fact that the original rice storage area was shared with foam equipment. By separating foam equipment, the number of pallets can then be reduced. The vacant spaces from the removed pallets can then be utilized as an auxiliary storage area, where advance order goods that are ready to be shipped can be temporary pack here. Note that the foam equipment was relocated to top of the shelves, since they are light weight and slow moving product.

Figure 33: Plastic bags on shelves (left), Foam equipment (centre), Plastic equipment (right)

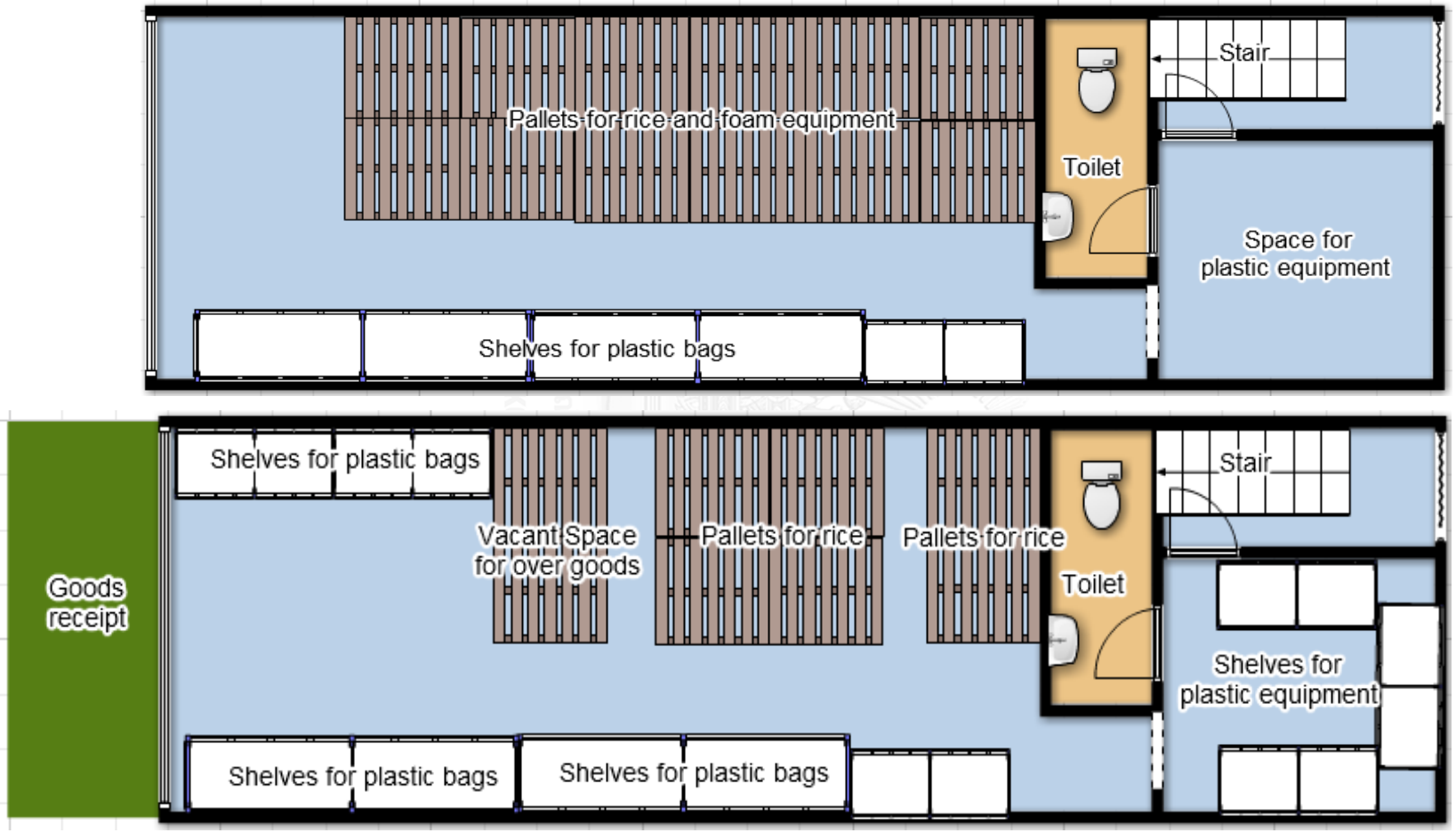


Figure 34: Comparison between old layout and new

In addition, pallets for rice storage, previously it was stored together with foam equipment but after the storage implementation, foam equipment was moved out while the numbers of pallet for rice storage still remain the same at 6 pallets. The implementation on inventory part has reduced the number of rice stocking. Also there are only 2 rice suppliers which are Supplier E and Supplier F. For supplier E has 5 types of rice while supplier F has 2 types. Therefore for rice arrangement can be done by lot categorisation for easy picking according to FIFO system. The stocking volume for supplier E is 41 sacks and 33 sacks for supplier F according to Table 29 below.

Table 29: Quantity in each type of rice

Supplier	Brand/Types	Number of sack
Supplier E	A. Sticky rice brand Doung-Jai	25
	B. Jasmine rice brand Sam-Ngou	7
	C. Rice brand Mung-Korn	4
	D. Rice brand Hip-po	3
	E. Pink coarse rice	2
Supplier F	F. Jasmine rice brand Dai-No-Sao	28
	G. Brown coarse rice	5

From Table 29 in order for easy understanding of rice arrangement and lot categorisation for rice picking, figure will be used in explanation and as well represent type of rice by letter A-G. New layout for rice rearrangement can be divided into 2 sections as there are 2 suppliers which supplier E has higher volume and more type of rice than supplier F and also Supplier E has cycle time in every 7 days while Supplier F has to make an order every 15 days. So supplier E is located first rice zone which is sitting right next to vacant space and has 4 pallets putting next to each

other. On the second rice zone for supplier F, there is only 2 pallets which locate next to the innermost wall.

Rice arrangement which was already mentioned in capacity of goods part in as-is analysis section, chapter 3, that 2 pallets can have 3 stacks of rice, and each stack can have 15 sacks which each type is put separately.

First part for rice arrangement by supplier E can be divided into 2 subsections which first subsection is the first 2 pallets when entering into storage area, the pallets are for 2 stacks of type A rice due to the calculation of target point in inventory management that 25 sacks is the highest volume which one stack can only have 15 sacks. Therefore 2 stacks are needed for this. For the remaining vacant space on this first subsection pallet is for the new lot of goods. And the second subsection of this rice pallet for rice type B, C and D&E in 3 stacks, respectively. The reason why type D and E are put together is because target point of type D has 3 sacks and type E has only 2 sacks which low number. For picking up of rice, type A has 2 stacks, hence it is necessary to finish one stack at a time due to sold of goods then add up the new rice sacks from supplier on the empty stacks (one stack replace the vacant space and another one replace sold stack), but need to finish the previous order of rice first, like first in first out, before start picking from the new lot on another stack. For type B, C and D&E rice, quantities on these stacks are low, therefore removing the previous order of rice out and putting the new lot in does not require much of an effort or hard work. This is in order for the worker to pick up and finish the old rice first before moving to the new lot. See Figure 35 for explanation.

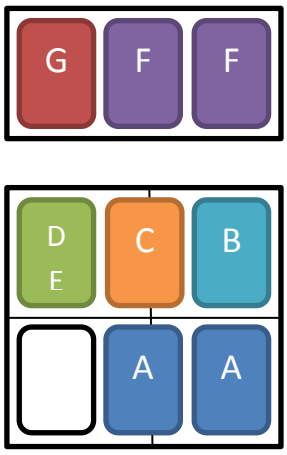


Figure 35: Layout of rice

For second part of rice zone by supplier F, as mentioned previously that there is two pallets which has 3 stacks and sit right next to the innermost part of wall. This supplier has only 2 types of rice which are type F and G, for type F has target point of 28 sacks, which requires 2 stacks to be put up, while type G has only 5 sacks. So picking up of type F rice has to be done by finishing one stack at a time due to selling. Therefore when the new orders came in to fill up, there will be an empty space for this new lot of rice to put, due to sold of goods, but if the old lot of rice still remained, removing the old lot out and placing on top of the new lot must be done in order for the old lot to be sold first.

In conclusion, from the storage management together with implementation on inventory will lead to good and effective storage management system, making the storage process run more systematic as well as in well order. Therefore this new rearranged layout will result for more efficient use of storage area.

5.2 Capacity of goods

The following criteria should be taken into account when considering the storage capacity for each type of goods: 1) how much should be kept for each category and 2) how much and how frequent should goods be ordered from the supplier. According to the purchasing policy, stated in Chapter 4, by reducing the amount of purchased goods and increase the frequency of supplier ordering, the amount of goods stored in the storage will be significantly reduced as shown in Table 30.

Table 30: The change of quantity in each product

Products	Previous quantity	New storage quantity
Plastic bags	198 packs	160 packs
Rice	115 sacks	74 sacks
Plastic equipment	40 boxes	>50 boxes *
Foam equipment	1 small truck load	1 small truck load

* Explanation in paragraph below

From Table 30 and Figure 36, it can be seen that the numbers of stored goods decreased, with an exception of plastic equipment, due to the increment of shelves in plastic equipment zone. Note that with an escalation in storage capacity and utilizing the same amount of frequency of resupply, the shop decided to add variation of goods, such as a new, unannounced, and sample products. This altered the records of the plastic equipment, resulting in an increment in plastic equipment storage. The storage capacity of plastic bags remained the same, even though the quantity of goods were reduced, since the new layout, which enable better categorisation by brand and type and ease of access, required more storage spaces.

When the storage area has been increased while the goods are reduced. Therefore, each of space on shelve would have more empty space, making the storage area management more effective in categorisation by type of goods for easier picking. Categorisation by size and volume of the same type of goods, for example PE 5x8 are put in one shelve which separate from PE 6x9, as originally everything are put together to make enough space for storage. Therefore the arrangement of 83 types of plastic bags will be scattered all over the area with separation by type categorisation. Plastic Bags are still the main goods with the highest share in storage area. For rice and foam equipment, the storage area was significantly shrunk. Rice which still can be seen that the storage area still remain the same at 6 pallets but more empty space are gained as previously the pallets' area were fully used by stacks, but after implementation policy has been set up and used, more empty spaces on pallets are increased and this has made lot arrangement with categorisation possible to use for more convenient of picking. In particular, foam equipment resupplying cycle was decreased due to the declination of demand. Taking foam to stock at the unused space to maximise the use of space, in this case is the top shelve. With plenty of space on top shelve for storing all foam equipment as this location cannot be used by other goods because limitation of appearance, for example rice which is too heavy to be placed on top shelve. Therefore this would make a good use of space as well as reduce the order volume which at the same time will reduce the stocking unit. With an improved layout and smart resupplying strategy, storage capacity of the storage is significantly raised, with up to 20% increase in vacant space which corrects the issue of storage area demand in the future. Moreover, implementation of inventory management in purchasing part is resulted in enough of goods order to meet with the customers' need and as well as reduce the unnecessary high volume order.

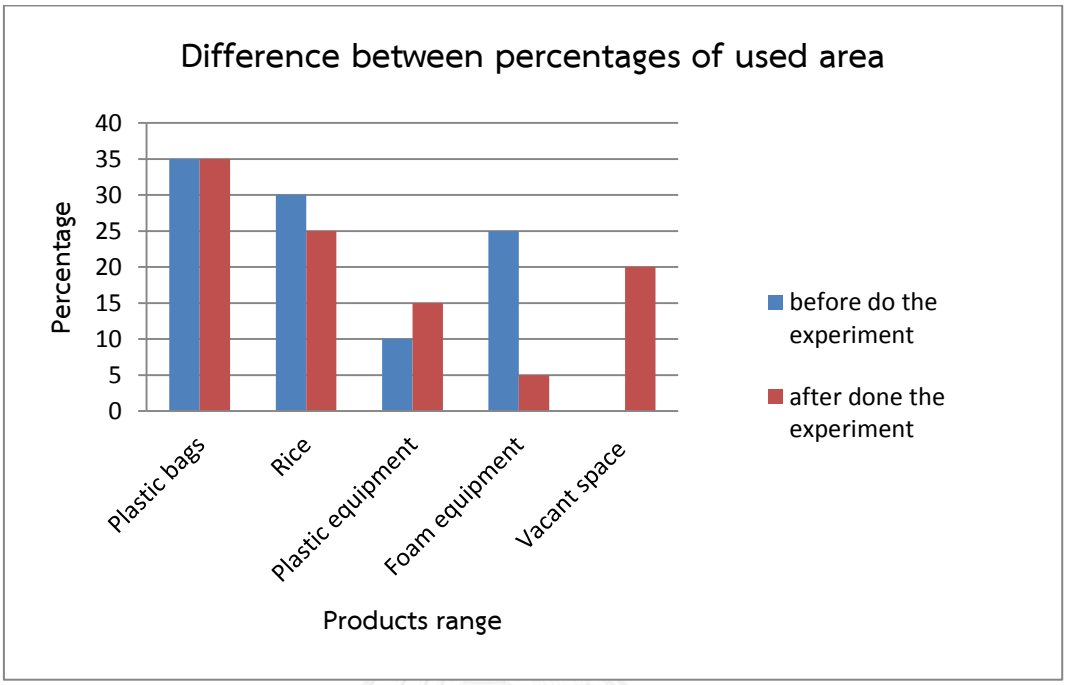


Figure 36: Difference between percentages of used area

5.3 Picking Time

The time taken to acquire the goods from their respective storage location is the best storage enhancement indicator. The collection duration directly reflects the layout and effort put in categorising the storage goods. Good storage layout includes strategic storage location, where the goods usage frequency is considered, and smart labelling for faster and easier collection.

After the storage enhancement was implemented, it can be seen that the time taken to acquire any type of goods is significantly reduced. Thus, further reducing the client waiting time, as shown in Figure 38, the collection duration for plastic bags and plastic equipment was considerably lessened. This was due to the fact that both plastic bags and plastic equipment were now labelled. Since different type of plastic bags have a very similar looking packaging, labelling can vitally improve visibility and effectively differentiating type of plastic bags, as shown in

Figure 37. Both plastic products were also placed on the shelves during the process of storage improvement, which is a lot easier to fetch than searching through the stack of goods that were scattered on the storage floor. Improvements on rice and foam products collection duration were not very significant, since the rice packaging for each brand were already clearly labelled. In addition, there were only 7 brands of rice and the workers were already familiar with this product type, thus, the collection time is already fast in the beginning. For foam equipment, since they were relocated from pallets to top of the shelves, the accessibility was reduced. Though, this drawback is not very significant, because the foam equipment have low access frequency.

Figure 37: Plastic bags with label to make it easier for finding

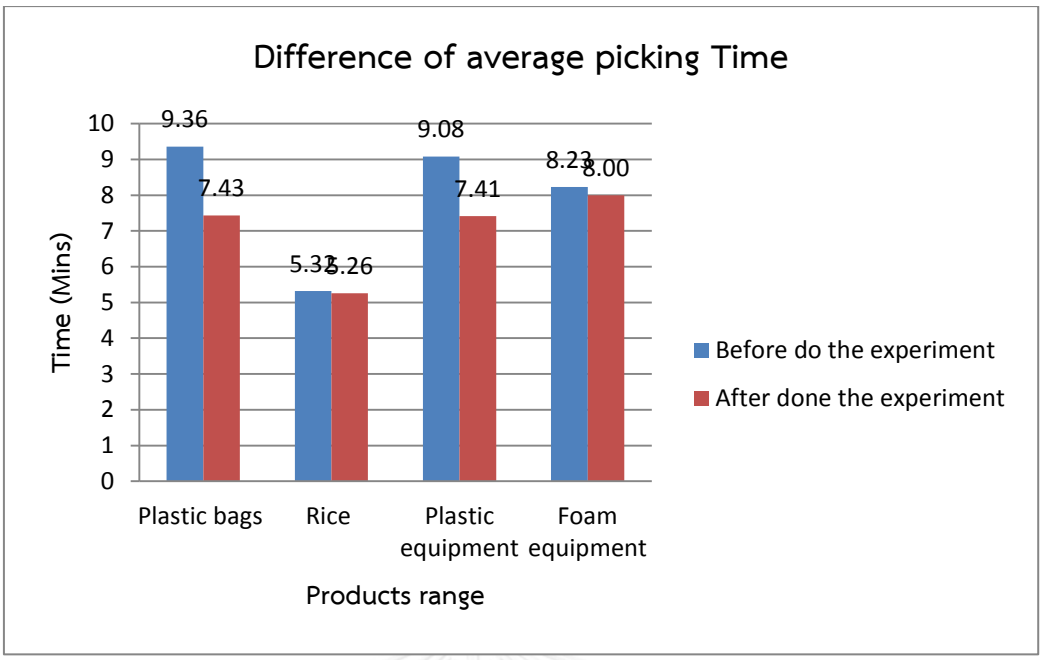


Figure 38: Difference of average picking time

5.4 Accuracy in stock record

The accuracy of stock record reflects the proper implementation of formal form of stock card, along with utilization of Microsoft Excel spread sheet application. Capabilities of the workers can also be accessed, as recommended in Chapter 4. The accuracy of stock record is as shown in Figure 39, where significant improvement in accuracy was achieved. Most of the remaining errors found in stock record were due to human errors, which include inputting incorrect value and neglecting stock card policy, where the workers simply forget to enter a checkout record when the goods were collected.

In addition to the newly implemented stock card system, the cycle count checking was also performed weekly, where the stock record was rechecked every week. Storage improvement, where goods were relocated to their respective categorised zone, also assisted in heightening the stock record accuracy, since the ease of goods counting was improved, further reducing the counting error.

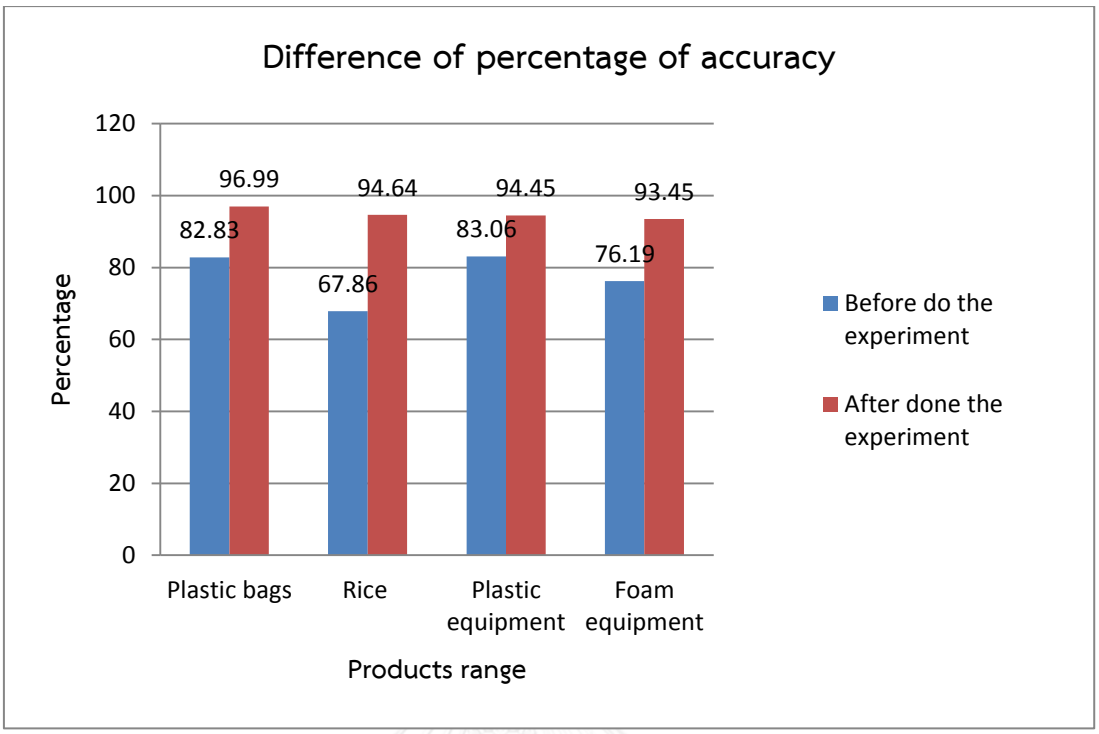


Figure 39: Difference of percentage of accuracy

5.5 Conclusions

The objective of this research is to focus on establishing inventory policy and improving storage operations in order to arrange and develop activities in storage to gain more efficiency of using space as well as better of storage management.

The scope of this research is to set the policies for managing and controlling all the activities doing in the storage. The mentioning activities in the storage are categorised into 2 main topics which are storage management and inventory management. Storage management will have layout set, create the operational process and set storage policies. For inventory management will have to create stock card, set purchasing policy, and set checking policy.

After having the clear study of objective and scope then the focus will move to the on-going issues from root cause analysis which can be categorised into 3 causes those are;

1) Inefficient use of storage – The main causes were that there is no system, no good layout, and no arrangement in storage process.
2) Inaccuracy in stock record – The main causes were as there is no inventory managing system as well as no form of stock card for recording which makes the record error and mistaken.
3) Low service level in term of time picking goods – This issue is the problem which cause by inefficiency of storage usage that was mentioned on number 1 cause. But on this case is a clear issue which was obtained by customers' complaint, therefore it is being separated into another main topic for specifically measuring the improvement on this point

When having a clear understanding of the on-going problems then data collection must be started in order to study the current activities in the storage at specific time. Data collection is separated into 4 main agendas which are capacity of goods, time of picking, accuracy record and purchasing data in order to see the efficiency of the storage usage before starting the improvement as well as to compare before and after activities in the storage.

When finished collecting all the data then the improvement process of the storage will be started. The improvement can be split into 2 parts. First part is the storage improvement while second part is inventory improvement.

Storage improvement starts with categorising goods with ABC analysis and frequent of picking, the result obtained was plastic bags which is a category A or fast moving type that is being picked up very frequent and need to consider important for stocking. Next is rice which is category B or Medium moving type that is being picked not as frequent as plastic bags. The other two types of goods are plastic equipment and foam equipment which are considered as category C or slow moving type. Next step is setting of layout by considering frequency or how often those goods are picked up as well as the appearance limitation of each goods. After clear

layout is set, next is the storage process which starts from receive of goods, identification and sorting of goods, labelling, putting away and the last is recording into the stock card. Setting of policy is required for worker to strictly follow and obey.

For inventory improvement, the process starts from setting of purchasing policy and require the use of combined Fixed – Time Period Ordering System together with Fixed – Order Quantity System by considering the appropriation and allowing flexibility in order to adapt to the current situation at specified time. Next is stock card creation by using Microsoft Excel. Stock card checking policy is then set in order for worker to understand and make way for them to work correctly.

After finishing the storage activity improvement, last step is measurement and study for the change or improvement by collecting the after improvement data same method and detail as when collecting the data before improvement. Because having the same factor and variable is necessary for data control. The result gained is useful to the shop as shown on Table 31 which states for the effect after the improvement that zoning in storage is clearly set for goods stocking and especially most important vacant space has increased by 20% compared with fully use of space in the beginning. Then the result on second part shown that accuracy in stock record has been changed most on rice by 26.78%, second is foam equipment 17.26%, then plastic bags with 14.16% and least accuracy improvement is plastic equipment with only 11.39%. However, the results of improvement for all the goods are shown in a better way with accuracy improvement of at least more than 10%. At last, the result of time of picking is shown that plastic bags and plastic equipment have both reduced the time of picking by almost 20% which is quite different from the reduction time of rice and foam equipment that dropped as little as 1-2%. But even with this little change, rice still has the least time of picking. From all these analysis, it is obvious that the activities for storage improvement have shown increase and

improvement in storage management in a better way which is very useful to use in the storage.

The shop has achieved the following benefits as below:

- Better storage condition – tidy arrangement, in order, and clean which makes the damage of stocked goods for both stay long on shelves or goods overlapping reduced.
- Short time of the operational process in storage – when having a good system and policy, following the step can be done with reduction of time wasting for example, clear type of goods zoning which allow the worker to save time looking for location or area for stocking goods or in case of finding goods, label policy can help reducing the time use for finding of goods as well
- Better in inventory control – ordering and stocking of goods from supplier are reduced which help the shop owner reducing the duration of keeping goods and lower the inventory carrying cost but still be able to respond to the need of customer. And for management of record and checking policy which help unveiling and showing the quantity of goods in inventory with high accuracy and correct information.
- Better Customer Satisfaction – Time of goods picking from storage is reduced, customer do not have to wait long for goods purchase and can be confident that there are needed goods

Table 31: Benefit from the research

Expected benefit	KPIs	Change
1. More efficient use of storage	Storage Management	- New layout of storage - Zoning - Increase 20% vacant space - Storage policies were set
2. More accuracy in stock record	Accuracy in inventory	- Formal stock card and cycle count sheet - + 14.16% of accuracy in plastic bags - +26.78% of accuracy in rice - +11.39% of accuracy in plastic equipment - +17.26% of accuracy in foam equipment
3. Increase service level	Time of picking goods	- -20.62% of picking time in plastic bags - -1.13% of picking time in rice - -18.39% of picking time in plastic equipment - -2.79% of picking time in foam equipment

5.6 Suggestions

Further monitoring of the storage improvement, including the storage management, inventory management, and workers skills development, is recommended. Additional enhancements of storage should also be implemented. This includes additional product zone signs, ladder for out of reach shelve locations, and extra cleaning to prevent animal associated hazards. Employee trainings, regarding the new stock card policies, are also recommended.

REFERENCES

Apiprushchayasakoun, K. (2007). *Warehouse Management* Thailand: CY System Printing.

Apiprushchayasakoun, K. (2011). *Inventory Management* Thailand Focus Media.

Arrand, M. (2008). Reorder point (ROP) control [Online] Available from: www.supplychainview.com/blog/?p=88 [Accessed 15 June 2014]

Brooks, R. B., and Wilson, L. W. (2007). *Inventory Record Accuracy: Unleashing the Power of Cycle Counting* (2 ed.): Wiley.

Edgar, C., and Tanyildiz, D. (2009). *Warehouse Analysis and Improvement for Farggrosen: A Multiple Case Study.* (Master Degree), Linkoping University.

Gonzalez, J. L., and Gonzalez, D. (2010). *Analysiss of an Economic Order Quantity and Reorder Point Interview Control Model for Company XYZ.* (Bachelor of Science Senior project), California Polytechnic State University San Luis Obispo.

Heragu, S. S., Du, L., Mantel, R. J., and Schuur, P. C. (2007). Mathematical model for warehouse design and product allocation. *International Journal of Production Research, 43*(2), 327-338.

Kalla, S. (2009). Calculate Standard Deviation. *Retrieved Mar 29,2015 from Explorable Psychology Experiment*.

Kittithreerapronchai, O., and Phumchusi, N. (2014). Warehouse Management System. *Engineering Journal, 5*(2).

Koster, R. d., Le-Duc, T., and Roodbergen, K. J. (2006). Design and control of warehouse order picking: A literature review *European Journal of Operational Research*.

Piasecki, D. Order Picking: Method and Equipment for Piece Pick, Case Pick, and Pallet Pick Operations. [Online] Available from: *Inventoryops.com*. [Accessed 12 May 2014]

Piasecki, D. J. (2009). *Inventory Management Explained: A focus on Forecasting, Lot Sizing, Safety Stock, and Ordering Systems.* (1 ed.): Ops Publishing

Roodbergen, K. J., and Petersen, C. G. (1999). *How to improve order picking efficiency with routing and storage policies, Progress in Material Handling Practice: 1999, G.R. Forger et al.(eds.).* Paper presented at the Material Handling Institute, Charlotte, North Carolina.

Schwarz, L. B. (2008). The Economic Order-Quantity (EOQ) Model. Purdue University

Slater, P. (2010). The Mechanics of Inventory Management *Smart Inventory Solutions: Improving the Management of Engineering Materials and Spare Parts* (2 ed.). New York, the United States of America Industrial Press Inc.

Stevenson, W. J. (2001). Operation Management 7th Edition. United State of America McGraw-Hill School Education

Stevenson, W. J. (2005). *Operations Management Eighth Edition*. New York, the United State of America: McGraw-Hill.

Tharathup, C. (2010). *A Logistic Cost Analysis and Cost Reduction: A Case Study of an industrial Adhesive Company* (Master degree), King Mongkut's University of Technology Thonburi, Thailand.

Tompkins, J. A., and Smith, J. D. (1998). *The Warehouse Management Handbook* (2 ed.). United States of America: Tompkins Press.

Wild, T. (2002). *Best Practice in Inventory Management* (2 ed.). New York, the United State of America John Wiley & Sons, Inc.

APPENDIX

APPENDIX A: Stock Keeping Units (SKU's)

Suppliers	Brand	Colour	Type / Code
Plastic bags Supplier A	1. Brand Bou-Ban		6 x 11
			6 x 14
			8 x 16
			9 x 18
			12 x 20
			12 x 26
Plastic bags Supplier B	2. Brand Rod-Tour		6 x 11
			6 x 14
			8 x 16
			9 x 18
			12 x 20
			12 x 26
	3. Brand Sam-Nok	White-colour	6 x 11
			6 x 14
			8 x 16
			9 x 18
			12 x 20
			12 x 26
		Pink-colour	6 x 11
			6 x 14
			8 x 16
			9 x 18
			12 x 20
			12 x 26

Suppliers	Brand	Colour	Type / Code
Plastic bags Supplier C	4. Brand Poo	Green	6 x 11
			6 x 14
			8 x 16
			9 x 18
			12 x 20
		Pink	6 x 11
			6 x 14
			8 x 16
			9 x 18
			12 x 20
		IPP	4 1/2 x 7
			5 x 8
			6 x 9
			7 x 11
			8 x 12
			9 x 14
			10 x 15
Plastic bags Supplier D	5. Brand Koun-Jae	Thick bag	6 x 14
			8 x 16
			9 x 18
			12 x 20
			12 x 26
			14 x 28
			15 x 30
		100 Piece	6 x 11
			6 x 14
			8 x 15
			9 x 18

Suppliers	Brand	Colour	Type / Code
Plastic bags Supplier D	5. Brand Koun-Jae	PE	4 x 6
			5 x 8
			6 x 9
			7 x 11
			8 x 12
			9 x 14
			10 x 15
			12 x 18
			14 x 22
			20 x 30
			30 x 50
		HD	5 x 8
			6 x 9
			7 x 11
			8 x 12
			9 x 14
			10 x 15
			12 x 18
			14 x 22
			20 x 30
			24 x 36
		Trash bags	20 x 30
			26 x 30
			28 x 36
			30 x 40
			36 x 45
			40 x 50

Suppliers	Brand
Rice from Supplier E	1. Sticky rice brand Doug-Jai 2. Jasmine rice brand Sam-Ngou 3. Rice brand Mung-Korn 4. Rice brand Hip-po 5. Pink coarse rice
Rice from Supplier F	1. Jasmine rice brand Dai-No-Sao 2. Brown coarse rice

Plastic Packaging	BP 02
	BP 03
	BP 04
	BP 05
	BP 15
	BP 16
	BP 17
	BP 18
	BP 25
	BP 26
	B 3
	R 2
	R 3
	R 5
	R 6

Microwave Packaging	B1 500
	B1 750
	B2 1000
	C1 120
	C1 650
	C2 500
	C2 1000

Rice Box	BR 402
	BR 503
	750 ml

GPPS Plastic glass	GPPS 3 Oz
	GPPS 4 Oz
	GPPS 6 Oz
	GPPS 7 Oz
	GPPS 10 Oz
	GPPS 12 Oz
	GPPS 16 Oz
	GPPS 22 Oz

Chang Plastic glass	3 Oz
	4 Oz
	6 Oz
	7 Oz
	10 Oz
	12 Oz
	16 Oz
	22 Oz

Paper glass	6.5 Oz
	8 Oz
	22 Oz

Foam	104
	107
	111
	203
	213
	215
	218
	243
	271
	302
	304
	306
	390
	402
	403
	404
	K 204
	Champ 5
	Champ 6
	Champ 8
	Box

APPENDIX B: Time of picking goods in each product

Table shows data collected from random of picking plastic bags in storage before do the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
May,9	7.43	9.55	9.39	8.18	10.54	9.02
May,16	8.32	5.43	9.45	7.52	11.19	8.38
May,23	10.38	9.41	11.31	6.22	7.51	9.37
May,30	5.46	8.43	10.11	9.32	9.12	8.49
June,6	5.21	12.39	12.28	7.13	9.49	9.30
June,13	7.34	12.54	11.48	9.39	8.41	10.23
June,20	13.25	9.49	7.31	7.59	5.16	8.56
June,27	7.48	10.31	6.25	7.51	8.04	8.32
						9.36

Minimum Time = 5.16 minutes

Maximum Time = 13.25 minutes

Table shows data collected from random of picking rice in storage before do the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
May,9	5.32	4.57	5.24	5.56	4.34	5.01
May,16	4.36	4.19	6.13	4.38	5.11	5.23
May,23	3.57	5.58	6.54	5.33	5.21	5.25
May,30	4.56	3.59	5.32	4.26	5.49	5.04
June,6	4.57	5.17	5.45	5.31	4.49	5.00
June,13	5.58	6.34	6.01	5.31	5.37	6.12
June,20	5.11	4.39	6.28	5.32	5.49	5.32
June,27	4.48	5.31	5.34	6.32	6.41	5.57
						5.32

Minimum Time = 3.57 minutes

Maximum Time = 6.54 minutes

Table shows data collected from random of picking plastic equipment in storage before do the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
May,9	9.32	7.50	6.19	9.58	6.17	8.15
May,16	7.41	11.44	8.31	9.17	10.11	9.29
May,23	13.25	6.11	8.40	7.19	10.01	9.39
May,30	8.31	14.28	10.17	9.46	8.53	10.15
June,6	10.01	8.54	9.13	8.49	9.22	9.08
June,13	8.55	9.30	7.04	8.54	8.21	8.33
June,20	8.36	9.52	9.09	10.00	8.46	9.09
June,27	8.41	8.55	11.34	9.03	8.43	9.15
						9.08

Minimum Time = 6.11 minutes

Maximum Time = 14.28 minutes

Table shows data collected from random of picking foam equipment in storage before do the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
May,9	5.22	7.19	6.58	7.51	9.00	7.10
May,16	6.06	8.57	7.45	7.39	6.38	7.17
May,23	8.50	7.39	9.41	8.51	8.57	8.48
May,30	7.33	8.52	9.43	8.16	6.46	8.38
June,6	9.12	6.38	8.31	7.59	10.30	8.34
June,13	7.57	10.11	8.42	7.39	7.44	8.19
June,20	5.41	6.31	8.13	8.24	9.40	7.50
June,27	6.08	8.54	7.11	8.26	7.21	7.44
						8.23

Minimum Time = 5.22 minutes

Maximum Time = 10.30 minutes

Table shows data collected from random of picking plastic bags in storage after done the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
July,11	7.48	6.33	8.20	6.16	7.49	7.13
July,18	8.20	8.12	8.57	7.39	8.28	8.11
July,25	6.47	8.10	8.41	8.34	7.47	8.16
Aug,1	7.30	5.41	8.12	7.11	7.00	7.39
Aug,8	6.54	7.31	7.19	8.02	7.39	7.29
Aug,15	7.00	6.57	7.59	7.13	7.27	7.11
Aug,22	6.55	7.21	6.74	7.01	8.49	7.20
Aug,29	7.45	7.59	8.45	7.38	6.39	7.45
						7.43

Minimum Time = 5.41 minutes

Maximum Time = 8.57 minutes

Table shows data collected from random of picking rice in storage after done the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
July,11	6.14	5.39	5.57	5.41	5.41	5.58
July,18	5.44	5.24	5.50	5.39	5.49	5.41
July,25	4.49	5.22	5.31	6.00	5.42	5.29
Aug,1	5.26	5.52	6.01	6.13	3.50	5.28
Aug,8	4.41	5.51	5.31	5.57	5.25	5.21
Aug,15	5.13	4.41	5.08	5.46	5.31	5.08
Aug,22	5.29	5.43	5.42	5.32	4.21	5.13
Aug,29	5.33	5.00	5.27	4.4	5.49	5.10
						5.26

Minimum Time = 3.50 minutes

Maximum Time = 6.14 minutes

Table shows data collected from random of picking plastic equipment in storage after done the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
July,11	7.59	8.51	8.22	7.39	8.56	8.05
July,18	6.59	7.44	9.36	7.12	7.46	7.59
July,25	7.21	7.15	8.32	7.18	8.01	7.57
Aug,1	8.20	7.18	7.00	7.04	6.53	7.19
Aug,8	7.58	6.42	7.49	7.32	7.22	7.21
Aug,15	6.15	7.41	7.35	8.20	7.40	7.30
Aug,22	7.31	6.58	7.28	7.39	7.24	7.16
Aug,29	7.28	7.30	6.51	7.56	7.33	7.20
						7.41

Minimum Time = 6.15 minutes

Maximum Time = 9.36 minutes

Table shows data collected from random of picking foam equipment in storage after done the experiment

Day/ Time	8.00-9.00	9.00-10.00	13.00-14.00	14.00-15.00	15.00-16.00	Average Time (Mins)
July,11	8.17	8.47	8.21	7.50	8.41	8.15
July,18	7.49	8.55	7.09	8.14	9.38	8.13
July,25	9.45	8.51	8.38	8.13	6.56	8.21
Aug,1	6.49	9.21	7.20	7.14	8.41	8.09
Aug,8	7.20	8.11	6.55	9.39	8.21	8.29
Aug,15	5.49	7.46	8.29	7.44	8.30	7.40
Aug,22	8.56	5.51	9.12	7.35	8.37	8.18
Aug,29	6.49	7.40	6.58	9.00	8.28	7.55
						8.00

Minimum Time = 5.49 minutes

Maximum Time = 9.45 minutes

APPENDIX C: Accuracy in stock record in each product

Table shows data of accuracy in plastic bags before do the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
May,11	83	69	83.13
May,18	83	68	81.93
May,25	83	71	85.54
June,1	83	65	78.31
June,8	83	68	81.93
June,15	83	73	87.95
June,22	83	67	80.72
June,29	83	69	83.13
			82.83

Table shows data of accuracy in rice before do the experiment

Date	No. of product Type	No. of accurate product type	% Accuracy
May,11	7	5	71.43
May,18	7	5	71.43
May,25	7	4	57.14
June,1	7	4	57.14
June,8	7	5	71.43
June,15	7	4	57.14
June,22	7	6	85.71
June,29	7	5	71.43
			67.86

Table shows data of accuracy in plastic equipment before do the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
May,11	45	36	80.00
May,18	45	34	75.56
May,25	45	37	82.22
June,1	45	39	86.67
June,8	45	38	84.44
June,15	45	37	82.22
June,22	45	40	88.89
June,29	45	38	84.44
			83.06

Table shows data of accuracy in foam equipment before do the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
May,11	21	12	57.14
May,18	21	14	66.67
May,25	21	17	80.95
June,1	21	16	76.19
June,8	21	18	85.71
June,15	21	15	71.43
June,22	21	19	90.48
June,29	21	17	80.95
			76.19

Table shows data of accuracy in plastic bags after done the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
July,13	83	79	95.18
July,20	83	81	97.59
July,27	83	80	96.39
Aug,3	83	79	95.18
Aug,10	83	81	97.59
Aug,17	83	80	96.39
Aug,24	83	82	98.80
Aug,31	83	82	98.80
			96.99

Table shows data of accuracy in rice after done the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
July,13	7	6	85.71
July,20	7	6	85.71
July,27	7	7	100
Aug,3	7	6	85.71
Aug,10	7	7	100
Aug,17	7	7	100
Aug,24	7	7	100
Aug,31	7	7	100
			94.64

Table shows data of accuracy in plastic equipment after done the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
July,13	45	41	91.11
July,20	45	43	95.56
July,27	45	41	91.11
Aug,3	45	44	97.78
Aug,10	45	42	93.33
Aug,17	45	43	95.56
Aug,24	45	44	97.78
Aug,31	45	42	93.33
			94.45

Table shows data of accuracy in foam equipment after done the experiment

Date	No. of product type	No. of accurate product type	% Accuracy
July,13	21	18	85.71
July,20	21	18	85.71
July,27	21	20	95.24
Aug,3	21	19	90.48
Aug,10	21	20	95.24
Aug,17	21	21	100
Aug,24	21	20	95.24
Aug,31	21	21	100
			93.45

APPENDIX D: z table

Standard Normal Probabilities

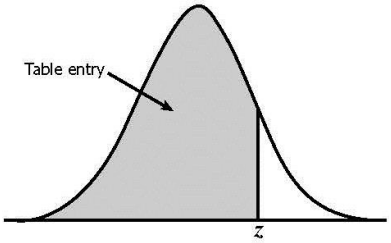


Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

VITA

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